ambition pour la biodiversité
BIODEV 2030

BIODEV2030 GUYANA [210701273_1]

REPORT STRUCTURE 12/10/2021

CEMCO Inc.

biotope

Table of content

Table of illustration

A. Introduction

A.1 Definition of biodiversity and its 3 levels

Biodiversity literally refers to the **diversity** of the living world (from the Greek bio (βίος) meaning "life"). Article 2 of the Convention on Biological Diversity defines it more precisely as *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".*

Biodiversity is assessed at **three levels**, considering the diversity of life forms at the ecosystem level (ecosystem diversity), species level (specific diversity) and genes level (genetic diversity). The **diversity of interactions** within and between these three levels of organization of living organisms, and the **functional diversity**, i.e., the diversity of functional characteristics of organisms, independently of the species to which they belong, are additional element of diversity to consider when one assesses biodiversity.

The usual measure of the level of biodiversity is based on lists of ecosystems, species and/or genes etc. (reference state), weighted by the number of species and genes (reference state) according to their rarity. The **depletion** of ecosystems, species and individuals, and the **disruption** of the interactions and functions that ensure their integrity are the two main criteria for measuring the state of biodiversity.

- **At the ecosystem scale,** the IUCN Global Ecosystem Typology 2.0, provides a functional description of biomes and ecosystems. It is the most comprehensive basis to date for this scale. It serves as the basis for a recently initiated categorization of the risks of ecosystem collapse: The Red List of Ecosystems[1]
- **At the species scale**, the IUCN Red List[2] is the most comprehensive global inventory. It provides information on the threat status of species (the risk of extinction), endemic or restricted species, and the abundances of certain species. **Specific richness** is the most common unit of measurement of biodiversity, and particular importance is given to "**bio-indicator" species**, which are particularly sensitive to changes in certain biotic or abiotic characteristics of their habitat. These data also make it possible to assess **the integrity of species' ranges**. The current collapse in the numbers and abundance of many species, a prelude to their eventual extinction, is focusing attention on the abundance of certain species that play an important **functional role** in ecosystems. Monitoring them is one way to learn about the overall state of the ecosystem and to identify changes in their environment at an early stage.
- Despite its importance, **intraspecific genetic diversity**, although it can be documented for some well-studied threatened species, is not likely to be used as a basis for impact assessment at the sectoral and national level in the short term. However, various initiatives are underway to use high-throughput analysis techniques (bar-coding, Clare et al., 2006[3]) for some species, and ecosystem compartments, including soils.

Thus, and particularly for the stakes of this study, we can consider the relative importance of an ecosystem for global biodiversity according to:

- **The endemism it hosts**
- **The species richness it hosts**
- **Its connectivity (functional role)**
- **Its role to mitigate climate change**
- **Other ecological goods and services rendered**

---

[1] *https://iucnrle.org/. Guyana's RedList of ecosystems isn't available yet.*
[2] *https://www.iucnredlist.org/*
[3] *DNA barcoding of Neotropical bats: species identification and discovery within Guyana - CLARE - 2007 - Molecular Ecology Notes - Wiley Online Library*

A.2 General description of Guyana biodiversity

Ecosystems: Guyana is situated in the **neotropical biogeographical territory** of northeastern South America and is part of the Guiana Shield region which forms part of the Amazon Biome.

The Amazon Biome, spanning 6.7 million km2, is the single largest remaining tropical rainforest in the world and is home to at least 10% of the world's known biodiversity (WWF-Guianas Wetlands of Guyana study, 2012), and **the Guiana Shield,** with an estimated age of 1.7-billion-year-old**,** is one of the oldest Precambrian geological formations on earth.

Formed in the Precambrian period, precisely in the Paleoproterozoic era (between 2.5 and 1.6 billion years ago), during which the first multicellular organisms appeared, this vast territory of approximately 1.8 million km2 offers today exceptional geographical characteristics (very high plateaus with particularly steep contours and dense tropical rainforests over most of its surface) including a variety of landscapes including sandstone tepuis, granite inselbergs, white sands, seasonally flooded tropical savannas, lowlands with numerous rivers, isolated mountain ranges, and coastal swamps, each supporting a characteristic vegetation[4], and rich biodiversity of animals and plants. It is also one of the continent's largest freshwater reservoirs. Finally, under the red earth of the oxisol and the black earth of the terra preta, there is a great concentration of precious minerals: gold, ilmenite, beryllium, bauxite, manganese, magnetite, kaolin, quartz, lithium, tantalum, molybdenum, garnet, uranium, diamond, niobium, chromium, nickel, tin, tungsten, copper, iron, barite, platinum, dolomite, as well as petroleum and natural gas... The Guiana Shield is of great ecological, biological and economic interest to the world.

This high and old diversity and endemicity of this biota accounts for its **high value for the global biodiversity.**

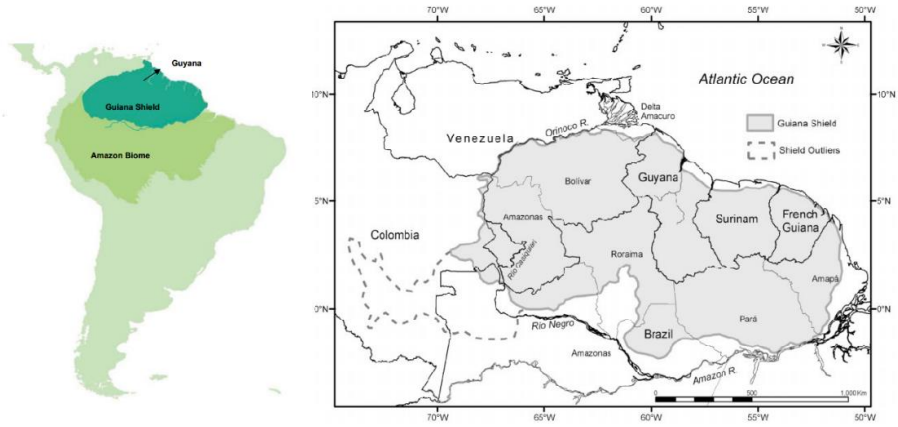


Figure 1 Guyana in relation to South America, Amazonia, and the Guiana Shield Bio-geographic Province. Source : WWF Living Guianas Report, 2012 [left] ; The Guiana Shield Region with the region of western outliers indicated. Source : Gibbs & Barron, 1993[5]

Guyana's area is 215,000 square kilometers (km2) with **forests covering a total of 87% of the country**. Nationally, the country land is considered as structured with four main natural landforms namely the coastal plain, the hilly sand and clay region, the forested highlands, and interior savannahs (Guyana's National Land Use Plan, 2013; Guyana Lands and Surveys Commission, 2017; Guyana Forestry Commission, 2018)[5]. Internationally, the FAO has mapped five separate physiographic regions namely the coastal plain; interior alluvial plains and low-lying lands the white sand plateau and older pediplains; crystalline shield uplands; highlands, mountains and plateau.

---

[4] Huber et al., 1995. In Checklist of the Terrestrial Vertebrates of the Guiana Shield, Hollowell, T., and R. P. Reynolds, eds. Bulletin of the Biological Society of Washington, no. 13.

5 The International Tropical Timber Organization has partitioned Guyana's forests as 36% rainforest, 35% percent montane forest, 15% swamp and marshes, 7% dry evergreen forests, 6% seasonalforest, and 1% mangrove forest (GoG, 2015b; Guyana Lands and Surveys Commission, 2013; ter Steege, 2000).

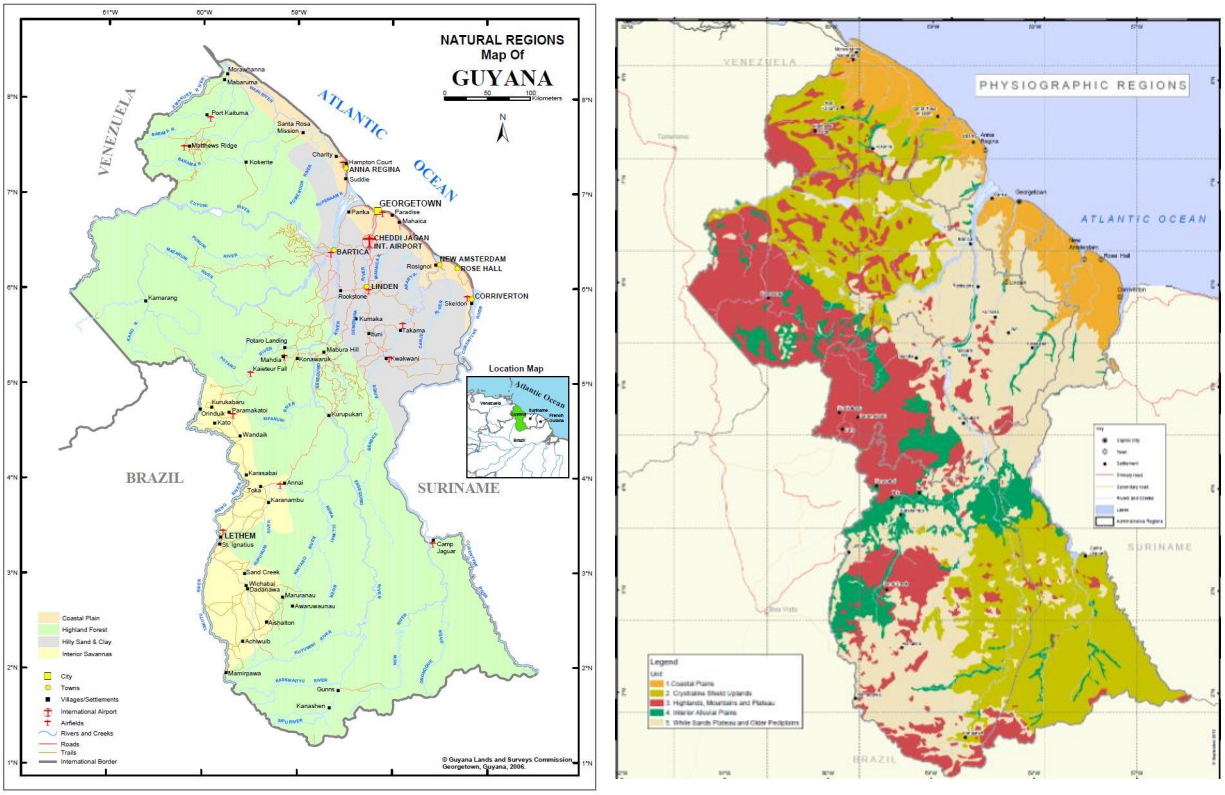


Figure 2 Natural region of Guyana. Source : Guyana Lands and surveys commission (GLSC), consulted on the 16th of september. [left] ; Physiographic region of Guyana. Source : Guyana National Land Use Plan, 2013[6] [right]

Based on the IUCN Global Ecosystem Typology 2.0., **twenty-seven ecosystems**[6] have been referenced in Guyana's landscape, and the last Guyana's national biodiversity strategy and action plan 2012-2020 (CBD) identified the following five major ecosystems: forest, freshwater, wetland, savannah, coastal and marine. According to the stakes of the study, we decided to distinguish the following ecosystems, as each ecosystem hosts different pressures:

(1) Coastal plain (including mangroves)
(2) The white sand plateau
(3) Tropical lowland rainforests (including alluvial forests)
(4) Highlands, mountains, plateau
(5) Savannas
(6) Water system (including freshwaters)
(7) Marine ecosystem

Species: There are **over 3,500 species of animals** that have been documented in Guyana. The breakdown is 467 fishes, 130 amphibians, 179 reptiles, 814 birds, 225 mammals and 1,690 invertebrates (FAO, 2015a; GoG, 2015b, 2019c). Approximately 33 species of bacteria, 13 species of nematodes and an estimated 30 viruses have been documented as of 2015. In terms of archaea and protist species, there were no records found that documented any archaea and protist species (GoG, 2015b, 2019c). To date, more than 1,200 species of fungal species have been documented in Guyana. Most of the documented

[6] *T1.1 Tropical-subtropical lowland rainforests; T1.3 Tropical-subtropical montane rainforests; T4.1 Trophic savannas; T4.2 Pyric tussock savannas; T7.1 Annual croplands; T7.3 Plantations; T7.4 Urban and industrial ecosystems; SF1.2 Groundwater ecosystems; TF1.1 Tropical flooded forests and peat forests; TF1.3 Permanent marshes; TF1.4 Seasonal floodplain marshes; F1.1 Permanent upland streams; F1.2 Permanent lowland rivers; F2.1 Large permanent freshwater lakes; F3.1 Large reservoirs; F3.3 Rice paddies; F3.4 Freshwater aquafarms; F3.5 Canals, ditches and drains; FM1.2 Permanently open riverine estuaries and bays; M1.5 Photo-limited marine animal forests; M1.8 Subtidal mud plains; M3.5 Deepwater biogenic beds; MT1.2 Muddy shores; MT1.3 Sandy shores; MFT1.1 Coastal river deltas; MFT1.2 Intertidal forests and shrublands; MFT1.3 Coastal saltmarshes and reedbeds*

species fall into phylum Basidiomycota (mushrooms) (Hance, 2008; HENKEL et al., 2002; Henkel et al., 2004; Smith et al., 2015).

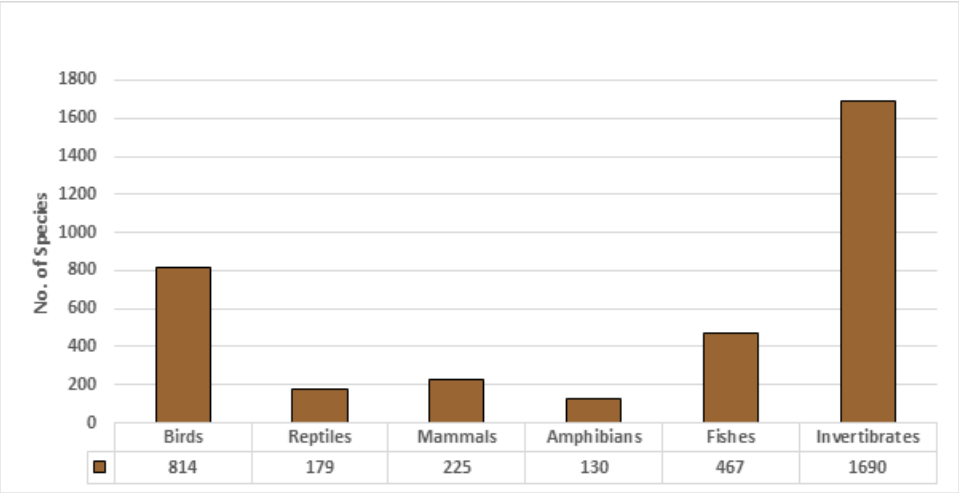


Figure 3 Number of species recorded per animal group in Guyana. Source: S.Hamer, 2021

On the IUCN red list **references 4559 species (high species richness)** among which 20 are critically endangered (CR), 58 are endangered (EN) and 106 are vulnerable (VU). Among the 20 CR species there are 14 are fish with 13 chondrichthyans and the Nassau Grouper *(Epinephelus striatus),* 2 birds (*Cercomacra carbonaria, Synallaxis kollari),* 4 are plants (*Magnoliopsida*). Some species are protected by the national law[7].

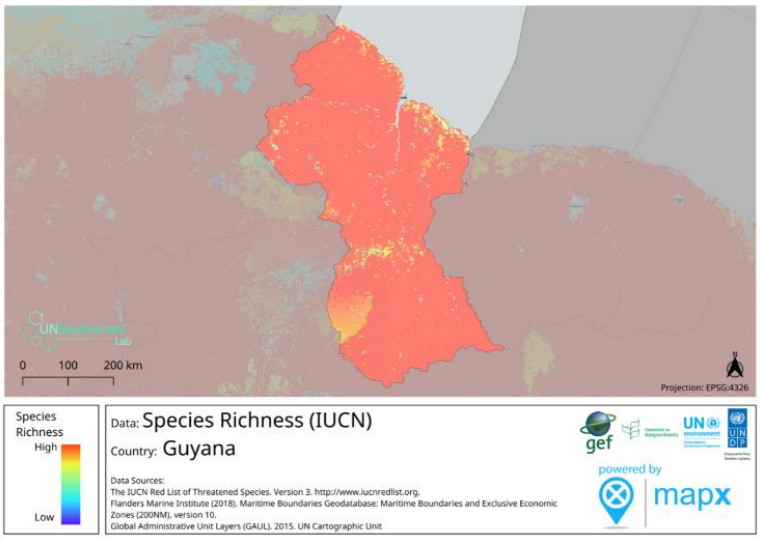


Figure 4 Specied Richness (IUCN) in Guyana. Source: GEF, UNCBD, UNEP, & UNDP, 2018

Endemism: As part of the wider phytogeographic entity of Guiana Shield, endemism in Guyana is either caused by accident (restricted range species) or if habitat contain endemic characteristics, confined to Guyana. Regarding local endemic plants, habitats such as white sands, serpentine rock, swamps, flood plains, rock outcrops and cloud forest[8] are where endemics plants are usually found. **The Pakaraima Mountains in Guyana has the highest level of plant endemism** in the country, followed by the upper Mazaruni-Kako-Roraima area where high concentrations of endemic species are known to occur and is

[7] *18x24 swm protected speices poster (wildlife.gov.gy)*
[8] *Gentry, A. H. 1992. Tropical Forest Biodiversity: distributional patterns and their conservational significance. Oikos 63: 19-28*

ranked the second most important area for endemism in Guyana[9]. Most of the endemic vertebrate fauna of Guyana are restricted to **highland areas**, especially at elevations greater than 1500m.

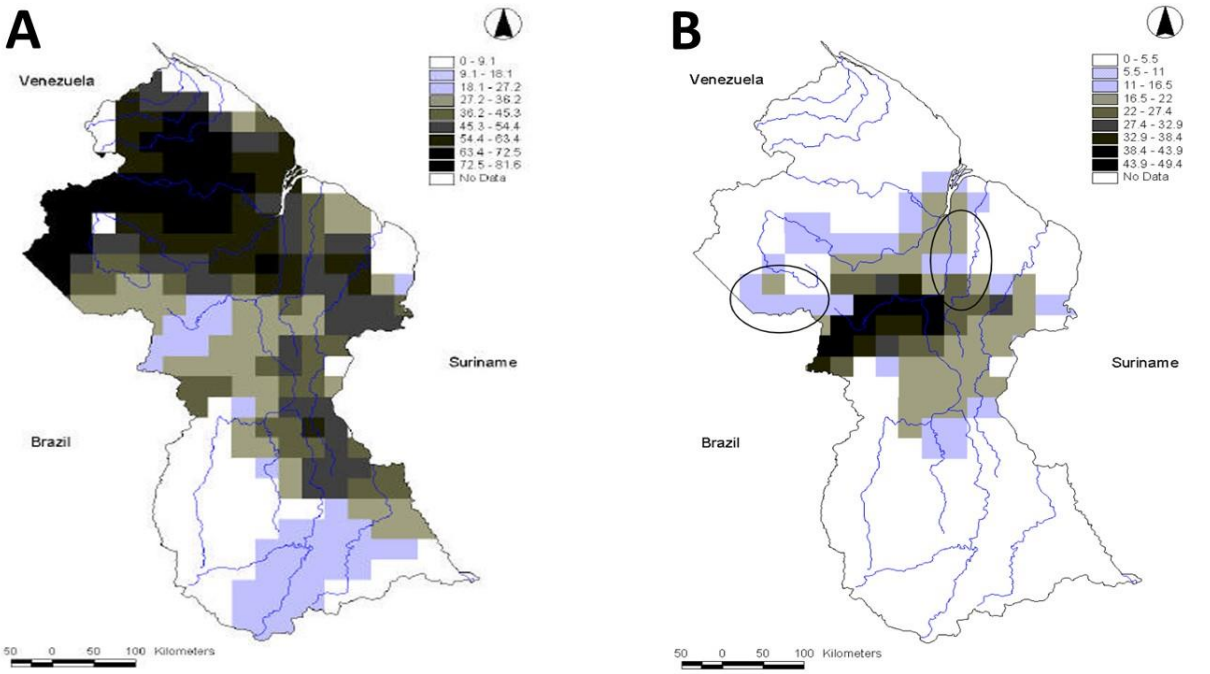


Figure 5 Maps of abundances. Source : ter Steege, et al., 2000

A: Map of abundance of individuals of species endemic to the three Guianas (excluding the species endemic to Guyana, which are in Figure 12.6), expressed as their percentage abundance in the forest community. Data is interpolated at 0.25-degree grid level with spatial inter- distance weighting up to 50 km

B: Map of abundance of individuals of true Guyanan endemics, expressed as their percentage abundance in the forest community. Data is interpolated at 0.25-degree grid level with spatial inter- distance weighting up to 50 km. The two main centers of species diversity of endemics (Chapter 6) are indicated by black ellipses (Upper Mazaruni R. - Kako and Potaro basin – Upper Demerara)

A.3 General description of Guyana's human profile and activities

Guyana's population is racially and ethnically diverse. The Indo-Guyanese, or East Indians, are the largest ethnic group (44% of the population), the second largest group is the Afro-Guyanese (30% of the population), and 17% of the population is of mixed heritage. Indigenous Amerindians represent 9% of the population and the largest indigenous groups of Guyana are the Arawaks, Wai Wai, Caribs, Akawaio and Arecuna.

[9] *Steege, H. ter, 2000. Plant Diversity in Guyana, with recommendations for a National Protected Area Strategy. The Tropenbos Foundation. Tropenbos Series 18.*

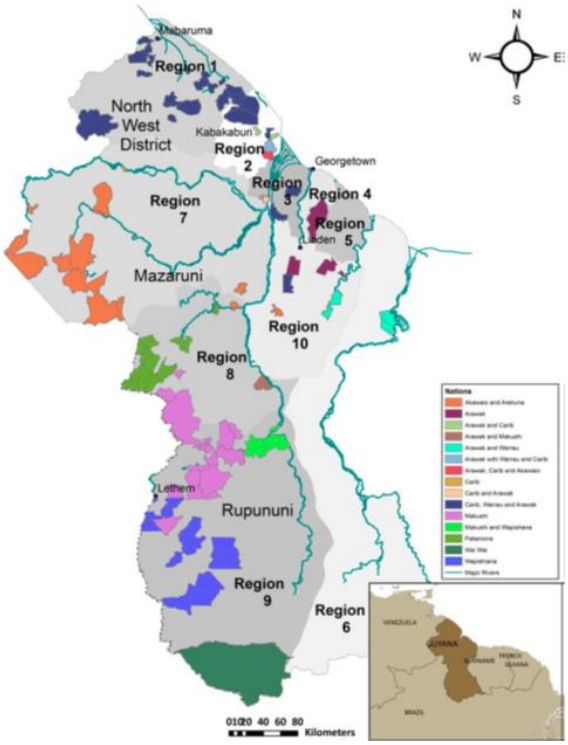


Figure 6 Map of Guyana showing 10 administrative regions, formally titled indigenous areas, and names of indigenous nations. Source: Anthony Cummings and Janette Bulkan, 2013

Guyana's population density is **very low** (3,49% in 2020), with 786,559 inhabitants (WorldBank, 2021) living on 215 000 km2 of lands. The country is among the 10 least populated countries in terms of land area (Indexmundi, 2021). Consequently, demographic growth isn't a great threat on biodiversity at the country scale. However, at regional scale, 90% of Guyana's population is living on the coastal strip, which accounts for only 10% of the total land area. This relatively high human concentration leading to a high concentration of impacts. According to the Guyana Labor Force Survey en 2018, roughly 12% of the population is unemployed, and half of the employed labour force is holding **informal jobs (48,6- 52,7%).** Most Guyanese working population is employed (formal jobs) in **agriculture (18,9%),** wholesale and retail trade (16-17%), public administration and defense (9,3%) and manufacturing sector (8,4%)[10].

Name	Population
Georgetown	235,017
Linden	44,690
New Amsterdam	35,039
Anna Regina	12,448
Bartica	11,157
Skeldon	5,859
Rosignol	5,782
Mahdia	4,200
Vreed-en-Hoop	3,073
Mabaruma	717

Figure 7 Population of Guyana. Source : World Population Review, 2021

A.4 Consequence of economic development on biodiversity

[10] *https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/GLFS_2017_Quarter4_Final-PDF-1.4MB.pdf*

Guyana heavily dependent on exports of gold, bauxite, and agricultural products (World Bank, 2021) and recently became the world's newest petrostate[11], meaning that a large part of the economic activity is **driven from external demand**. Several factors contributed to Guyana's dependency on external investment, starting from its colonial history to the global production mode being based on a growth paradigm (development models). The abundant ecological profile of the country led to the risk of being trapped in the **Dutch disease**, as biodiversity largely contribute to Guyana's economy with **95% of foreign exchange earnings being the result of using natural resources and biodiversity** (in year 2013, EPA, 2014).

The extraction of resources causes direct removal of biodiversity (minerals, fishes, trees, oil, plants) and indirect disruption of biodiversity being the result of land use changes, leading to the fragmentation of biological corridors, habitat, introduction of invasive species or diverse pollutions.

In Guyana a study has been made by the IUCN, according to the **IBAT analysis**. This assessment estimates the contribution that an investment can make over a geographic area to reduce the risk of species extinction by reducing existing risks (mitigation potential). This measure lists **the threats to species at risk (VU, EN, CR), which has the best mitigation potential**, and are the following in Guyana:

- Fishing & harvesting aquatic resources, on a large extent, category (5.4.)
- Logging and wood harvesting (5.3.)
- Housing and urban areas (1.1)
- Agro-industry farming (2.1.3.)
- Mining and quarrying (3.2)
- Agro-industry grazing, ranching or farming (2.3.3.)
- Hunting & collecting terrestrial animals (5.1.1.)

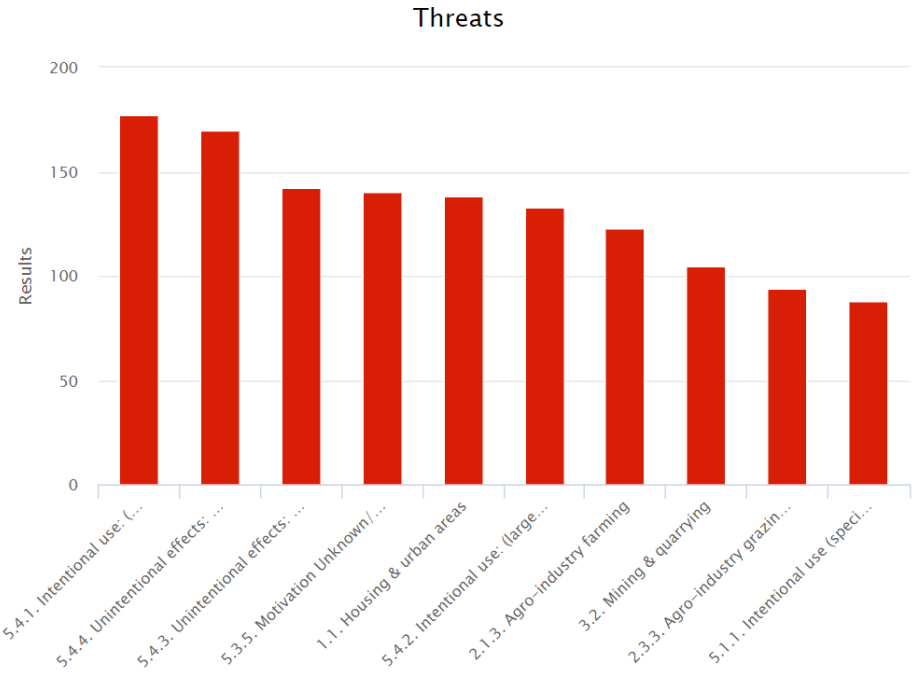


Figure 8 Threats to the species at risk having the highest mitigation potential. Source: IUCN, 2021

[11] *https://theglobalamericans.org/2021/04/saber-rattling-and-high-stakes-in-guyanas-geopolitical-neighborhood/*

In the last Guyana's national biodiversity strategy and action plan (2012-2020) some threats to Guyana's environment have been listed as follows (the words in italic have been added by the authors):

- **Direct threats,** resulting from developmental activities
  - **overfishing** and overhunting on commercial scales, *which is linked to the fisheries sector*
  - savannah and **forest fires**, in particular, in the Rupununi Savannahs and surrounding forested areas of the Kanuku Mountains, *which is linked to the agricultural sector*
  - indiscriminate **land-use practices** (mining, logging practices, agriculture)
  - **hinterland road** construction, *which is linked to mining, logging activities, and tourism, as well as infrastructures needs (energy, transport).*
  - uncontrolled harvesting and poaching of wildlife, *which isn't an economic sector*
  - uncontrolled harvesting of non-timber forest products, *which isn't an economic sector*
  - uncontrolled and inappropriate use of agro-chemicals and other human induced **pollution** such as indiscriminate disposal of solid wastes both hazardous and non-hazardous, *which can be linked to agriculture, but also any other sectors implying human work.*

- **Indirect threats**
  - climate change events and related natural disasters such as floods and droughts with ever increasing severity
  - institutional fragmentation and conflicting legislation
  - limited knowledge on species diversity, range, and behavior
  - insufficient monitoring and enforcement
  - limited relevant judicial awareness and experience.

Regarding **specific ecosystems**, the threats identified were:

- In forests and savannahs:
  - large scale **selective logging ("high grading")** of certain species
  - **fuel wood collection** in natural forests
  - unregulated chainsaw operations
  - conversion to **agriculture and other uses**
  - unregulated and unmanaged exploitation of **forest resources** in titled Amerindian communities
  - **mining** (legal and illegal)
  - over-harvesting of resources

- Inland aquatic
  - loss of **aquatic biodiversity** resulting from land and **river mining**
  - degradation of water quality due to **mining and agricultural practices**
  - introduction of potentially damaging **invasive species**
  - over-harvesting of **fisheries resources** with gill nets and sport fishing.

- Marine/ Coastal
  - excessive targeting of certain **marine species** of fish
  - introduction of **seine** for fish harvesting
  - degradation of water quality due to contamination from **solid and other waste**
  - illegal harvesting of **mangrove vegetation**
  - **poaching** of protected species – endangered sea turtles.

As well as the key emerging threats and pressures

- A threat to the **fishing industry**. A decline in fish catch of 6.5% in 2013 was attributed to overfishing
- **Human use of the mangrove belt** which has been severely depleted from heavy, to which the rise in sea level and increased wave force adds additional pressures. The **oil and gas industry** becoming a threat to the mangrove environments via the establishment of massive onshore bases.
- **Gold mining** which continues to increase and represent significative threats to the environment and biodiversity from chemical use, removal of trees and soil.
- **Tourism** has become a major worldwide economic activity, with tourist increasingly interested in visiting unspoiled and less-developed areas with low tourist density. Therefore, if the level of visitors is greater than the environment's ability to cope with the level of use, Guyana might incur negative impact on its biodiversity.

Finally, other contingent vulnerabilities were mentioned:

- **Climate change events and related natural disasters** are unpredictable weather patterns, that can affect the availability of water and food resources for some wildlife species, key fruiting trees, and more direct impacts may result from flash floods in some hilly regions
- Introduction of **Alien Invasive Species**, a total of 49 invasive species are known to occur in Guyana. Of these, 18 species are Alien (introduced), 28 are Native and 3 species with their bio-status not specified. Twenty-three (23), invasive species are found in agricultural areas, 21 in natural forests, 14 in coastlands, 18 in wetlands and 3 in marine habitats (Global Invasive Species Database, 2014)
- Increased accessibility to and economic activities in **hinterland areas**. The rapid opening up of areas to commercial activity may lead to clash of cultures and practices that may make local people more vulnerable to diseases, etc.
- **Vulnerability of Guyana's coastal zone** to flooding, erosion and salinization. Due to physio geography, Guyana's coastal zone being 1m below mean high tide levels of the Atlantic Ocean in some areas and expected increase of the sea level.

To **update and prioritize** those threat assessments, this diagnosis called **Report structure** offers a review of existing reports and literature on scientific knowledge/data (reports, literature, remote sensing etc.) on biodiversity pressures/threats and drivers of decline caused by the economic sectors in Guyana. The present document will serve the second part of the study, which purpose is to prioritize those threats according to a list of criteria, both quantitative and qualitative.

The report structure is divided in three parts as follows:

- **The main ecosystems of Guyana:** describing for 7 ecosystems, the habitats and species (1), Guyana's characteristically traits, at national or regional level (2), ecosystem services rendered (3), studies on the said ecosystem (4), protection status of the said ecosystem (5), criteria of importance for the ecosystem (6).
- **The main economic sectors of Guyana:** describing for 7 economic sectors, their contribution to national economy (1), their area of impact (2), the description of current impacts (3), the description of prospected impact (4)
- **Drivers of biodiversity loss on each ecosystem**: which is a preliminary identification of the relative importance of threats to biodiversity on each ecosystem, to be completed with stakeholders' workshops and with the prioritization analysis process.

B. Main ecosystems in Guyana

As previously mentioned, this study distinguishes the following ecosystems, which correspond to naturel region of Guyana, to which were added water system, marine ecosystem, and tropical lowland rainforests (including alluvial forests):

- Coastal plain (including mangroves)
- White sand plateau
- Tropical lowland rainforests (including alluvial forests)
- Highlands, mountains, plateaus
- Savannas
- Water system (including freshwaters)
- Marine ecosystem

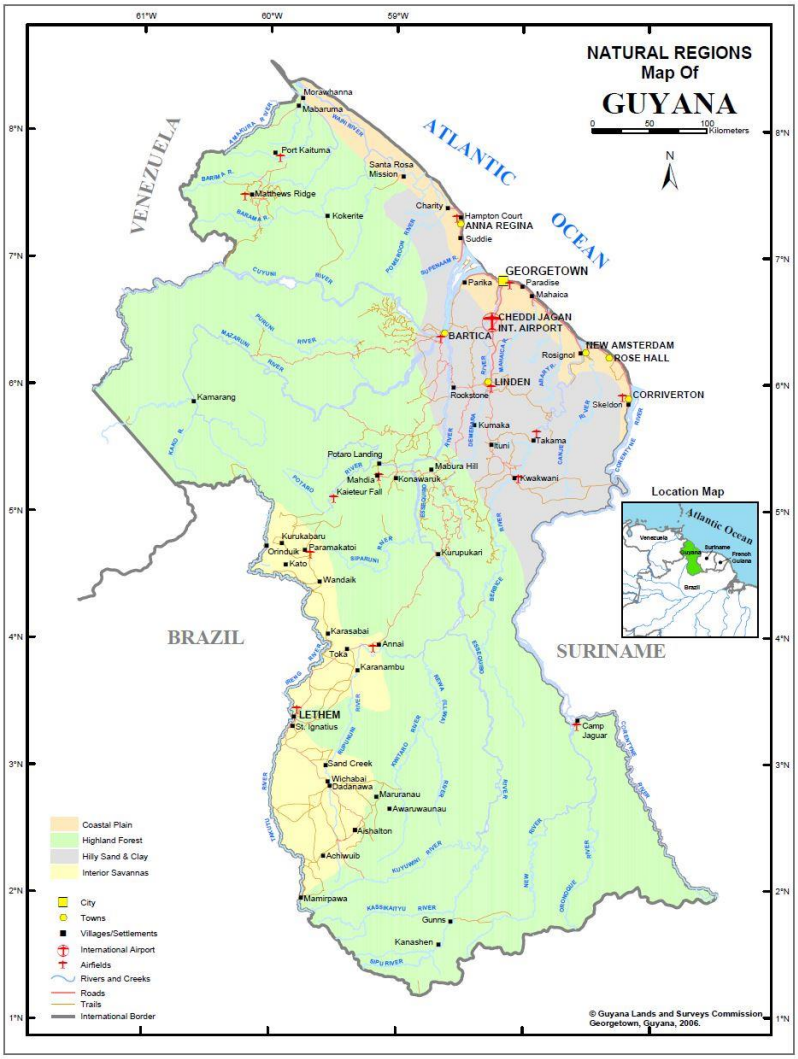


Figure 9 Natural regions of Guyana. Source : Guyana Land and Survey Commission, 2006

All along this section, for a better visualization, it is recommended to refer at the first annex which is the vegetation map of Guyana.

B.1 Coastal ecosystem

Habitats and species description

The coastal zone accounts for **4.3% of Guyana's total landmass** and varies in width from 8 to 65 km and a length of 440 km. Mangroves and swamps forest cover an estimated 22632.4 hectares of the coast (Jaikishun et al., 2017[12]) and are bordered inland by shallow saline and brackish lagoons and swamps, seasonally flooded palm marsh and forest of the old coastal plain (the Coropina formation) (Guyana's national biodiversity strategy and action plan, 2012-2020). Mangroves represents 0.12% of Guyana's forests, with 3 species occuring, which are *Avicennia germinans, Rhizophora mangle* and *Laguncularia racemosa* (Hussein, 1995). Swamp and marsh forests, dominant species are *Symphonia globulifera, Tabebuia insignis/fluviatilis, Pterocarpus officinalis* and *Euterpe oleracea,* and *Manicaria saccifera* is commonly found as a narrow belt along rivers. More inland forest composition is slightly different as the duration of flooding is less pronounced, and common species are *Symphonia globulifera, Virola surinamensis, Iryanthera spp., Pterocarpus officinalis, Mora excelsa, Pachira aquatica, Manicaria saccifera* and *Euterpe oleracea*.

Mangrove is a great habitat for wildlife and hosts birds as the scarlet ibis (*Eudocimus ruber*), species of invertebrate herbivores, reptiles, small mammals as the manatee (*Pteronura brasiliensis*), the mangrove doe (*Odocoileus cariacou*) and the raccoon (*Procyon cancrivorus*), juvenile fish, hard substrates for algal attachment and sessile and mobile invertebrates such as oysters, mussels, sponges and gastropods. Mangrove is also a **nesting ground** for the endangered Leatherback, *(Demochelys coriacea*), Hawksbill (*Eretmochelys imbricata*), Olive Ridley (*Lepidochelys olivacea*) and the Green turtle (*Chelonia mydas)*.

The Coastal Ecosystem Characteristic Traits

The coastal ecosystem of Guyana has particularities.

- **Mangroves on mud with inverted distribution**: even if Guyana is located at the end of the influence of the silt from the Amazon, it hosts mobile mangrove moving with the movement of mud banks (due to the longshore drift cycle). This phenomenon stops at the mouth of the Orinoco River. After the accretion of mud banks, mangroves develop towards the sea and then retreat. This **endemic phenomenon** is even visible on the vegetation as mangroves on mud with inverted distribution. In Guyana Red mangroves (*Rhizophora spp*.) appear in the most stable situations (at the back), followed by black mangroves (*Aviciennia germinans)* and white mangrove (*Laguncularia racemosa)* which colonies the mud banks with a rapid growth strategy, sign of a very productive environment, both on the terrestrial and marine part.
- **Specialized roots such as pneumatophores and stilt roots**: which allows the ecosystem services to be provided.
- **Ecotone:** which by nature is a buffer zone which contributes to a large extent to the resilience of ecosystems (land and sea)
- **Upland shrub/grass savannah**: on the eastern part of the coast, there is patches of upland shrub/grass savannas, which is very characteristic of Guyana. This vegetation is dry and easily flammable (more details in the savannas ecosystem section).

Ecosystem services, interest for global biodiversity

- **Filter:** Carbon and nutrients from buried detritus and/or decomposed by fungi and/or bacteria are mobilized at higher trophic levels, and the nitrogen use/resorption cycle is very efficient. Even pollutants in runoff from agriculture are absorbed (phytoremediation)
- **Blue carbon sink:** Mangroves host dense fast-growing trees whose development is accompanied by a significant production of litter, some of which remains buried on site by sedimentation or crabs. This dead wood, which decomposes very slowly due to the damp, oxygen-poor soil, forms impressive carbon reserves. Some studies show that mangrove in Guyana sequester approximately 17 metric tons of carbon annually (GEA, 2019[13]).
- **Nursery** for juveniles

[12] *https://smujo.id/bw/article/download/1777/1698/2041#:~:text=The%20total%20forest%20coverage%20of,to%200.257%20gigatonnes%20of%20CO2*

[13] *https://gea.gov.gy/wp-content/uploads/2019/07/A3-Sustainable-Management-of-Natural-Resources.pdf*

- **Protective barrier** against natural hazards, including flooding, storm surges, elevated tides, and erosion.
- **High structural importance** for beta diversity and gamma diversity, i.e., for the survival and recruitment of multiple species in poorly aerated, saline, mobile and tidally flooded substrates.

Studies on mangroves

- Jaikishun, Ansari, DaSilva, Hosen, Carbon storage potential of mangrove forest in Guyana, 2017
- Guyana's national biodiversity strategy and action plan, 2012-2020
- GEA, Sustainable Management of Natural Ressources Report, 2019

Protection status and vulnerability

Except from the shell beach, located on the northern part of the coast and protected since 2011, the coastline isn't protected. Covering an area of 125,000 ha, the shell beach represents 11% of the protected area system and 0.58% of the country's land mass. It is a combination of coastal forest and sandy coastline providing an annual nesting ground for four endangered marine turtles: the Leatherback, *(Demochelys coriacea*), the Hawksbill (*Eretmochelys imbricata*), the Olive Ridley (*Lepidochelys olivacea*) and the Green turtle (*Chelonia mydas)*. The area also encompasses a unique ecosystem of mangrove forests, inland swamp forests and savannahs. It is home to an array of species including manatees (*Trichechus manatus*), tapirs (*Tapirus terrestris*), deer (*Mazama americana*), jaguars (*Panthera onca*), howler monkeys *(Alouatta seniculus*), and other large animals. **The bird diversity is one of the richest in Guyana** with over 200 species of coastal and migratory birds recorded and includes a variety of parrots and macaws, numerous wading birds including many scarlet ibis (*Eudocimus ruber*) and Caribbean flamingos (*Phoenicopterus ruber*), the magnificent harpy eagle (*Harpia harpyja*), Hoatzin (*Opisthocomus hoazin*), Limpkin (*Aramus guarauna*), Mangrove rail (*Rallus longirostris*), Lesser yellowlegs (*Tringa flavipes*), Red knot (*Calidris canutus*) Roseate spoonbill (*Platalea ajaja*), Rufous crab hawk (*Buteogallus aequinoctialis*), Toco toucan (*Ramphastos toco*), Blood-colored woodpecker (*Dryobates sanguineus*), among a host of others.

However, a **mangrove restoration and management department** exist within the government-funded National Agriculture Research & Extension Institute (NAREI)[14], and the mangrove ecosystem is protected by law (legislative framework available in annex 2). The Government passed legislation, under the Forest Act, to make all mangroves in Guyana a **protected species**[15], and the Sea Defence Act explains that sea defence includes any natural feature which serves as a protection of the seacoast against the erosive action of the sea. However, despite this, the coastal ecosystem, and particularly the one located on the southern half, is highly vulnerable. It has the **highest forest cover loss in Guyana** (along with the savannas ecosystem), it is key usage area for water security (scarcity is a threat are all pressures are concentrated on this part of the coast), and there is in the same a **high potential of carbon sequestration**, mainly due to mangrove forests.

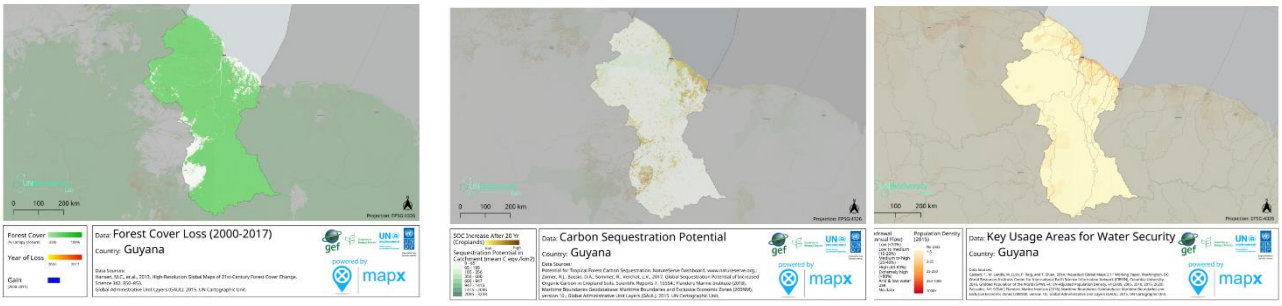


Figure 10 Forest cover loss; carbon sequestration; key usage area for water security. Source : GEF, UNCBD, UNEP, & UNDP, 2018

[14] *History of its creation: https://news.mongabay.com/2017/07/going-under-mangrove-restoration-in-low-lying-guyana-a-vital-need-say-experts/*

[15] *It is now illegal to destroy mangroves without prior permission from the Commissioner of the Guyana Forestry Commission*

The coastal ecosystem is therefore considered as a vulnerable ecosystem that is poorly protected.

Criteria of importance for the ecosystem

Endemism	Exceptional type of mangrove (mudbank)
Richness	High and diverse. Shell beach: the bird diversity is one of the richest
Connectivity	High importance for the ecosystem resilience
Climate change	High importance for mitigation as an inter-tidal vegetation, and high sequestration of carbon

B.2 The white sand plateau, known as Wallaba forests in Guyana

Habitat and species description

The sand plateau constitutes **13.7% of the total land mass** of Guyana, which makes it the second biggest ecosystem (after forest ecosystems, both montane and lowlands). White sand forest is characterized by their **soils, developed from old deltaic and continental deposits**, which explain their high content of iron and aluminum oxides, leading to saturation in those elements that may be a problem for plant growth (Kekem et al., 1997[16]), and this can be seen on the stand structure and leaves exhibit features (high density, low to medium height, sclerophylly and yellowish to reddish colour) that respond to oligotrophic soils and/or high drought sensibility (De Oñate-Calvín et al., 2013). Despite their poor nutrient content, those specific soils are known for **various minerals** such as bauxite and white clays (kaolin) and for their relative **dryness,** which make those ecosystems fragile due to their composition and to climate change. The sand plateau is dominated by shrub forests (Wallaba forests, *Eperua falcata*), dakama forests and muri scrub/white sand savannah, with lowland grass, mash forest and mixed forests. Trees are smaller than in the deep rainforest, and dry easily.

In terms of species, it is home to regional endemic species of reptiles, amphibians and birds as the red woodpecker (*Veniliornis sanguineus*), species of black manakin (*Xenopipo atronitens Cabanis*), golden-plumed black manakin (*Pipra erythrocephala*).

The white sand plateau's characteristic traits

- **Inheritance from the late Tertiary-Pleistocene:** White-sand forests are a complex of vegetation types growing on quartz-rich sandy soils across Amazonia as a result of extensive sediments being deposited in that period starting roughly 126 000 years ago. Those ecosystems represent **natural laboratories of evolution** over their long history throughout Amazonia and the Guiana Shield, and supports high levels of floral endemism (GoG, 2019).
- **Low alpha diversity with high endemism (species):** In Amazonia, those forests are scattered in island-like patches, and often dominated by a few species (and consequently have a low alpha-diversity), which are endemic, thus should be prioritized for conservation (Duivenvoorden 1996[17]; Alonso et al., 2013[18]).

Ecosystem services, interest for global biodiversity

- **Traditional use to build homes:** These wooded areas are disdained for cultivation or timber exploitation (oligotrophic soils), but nevertheless their small diameter stems, between 5 and 15

[16] *https://www.tropenbos.org/resources/publications/soils+of+the+rain+forest+in+central+guyana*
[17] *https://besjournals.onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2745.1999.00333.x*
[18] *Alonso et al., Habitat Specialization by Birds in Western Amazonian White-sand Forests, 2013*

centimeters, are highly durable and traditionally extracted by the local population to build their homes (De Oñate-Calvín et al., 2013[19]).

- **Medicinal value:** In French Guyana, similar forest is protected (Mana forest), especially for the presence of *Humiria balsamifera*, used for medicinal purposes[20].

Studies on white sand plateau

This ecosystem is **poorly studied** in Guyana. Neighboring countries as Peru or French Guyana start to focus on it, the most relevant paper being the ones of De Oñate-Calvín et al., 2013 and Alonso et al., 2013, showing that despite their fragility, these white sand forests advantages in terms of their management potential compared to other types of tropical rainforest considering the high frequency (26%) of valuable species, the remarkable dominance of a small group of species, most of which (67%) are of commercial interest.

Protection status and vulnerability

There isn't any protection status for white-sand plateaus despite its high soil particularities and great vulnerability to climate change. Moreover, in terms of species, a collaboration between GEF, UNCBD, UNEP, & UNDP (2018) shows that Guyana's white sand plateau, along with forest ecosystems, host a high percentage of threatened species.

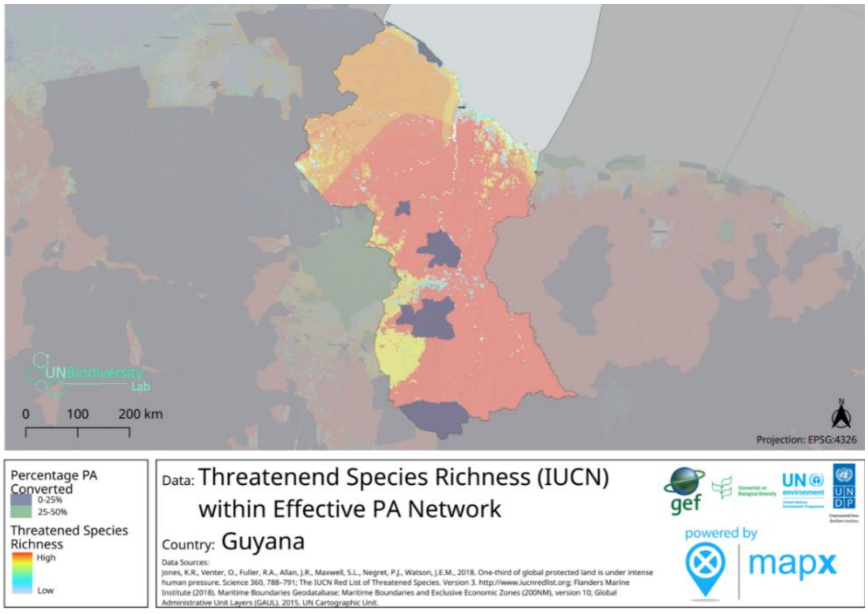


Figure 11 Threatened species richness (IUCN) with effective PA Network in Guyana. Source : Source: GEF, UNCBD, UNEP, & UNDP, 2018

The white sand plateau is therefore considered as vulnerable ecosystem that is poorly protected, endemic and sensible to climate change.

Criteria of importance for the ecosystem

Endemism	Oligotrophic soils and vegetation accordingly
Richness	High in minerals but low alpha diversity
Connectivity	Inheritage of the Tertiary-Pleistocen to preserve
Climate change	Fragility to climate change

[19] *Amazonian White-Sand Forest: A Black Future? https://revues.cirad.fr/index.php/BFT/article/view/20540/0*
[20] *https://www.guyane-amazonie.fr/sites-naturels-proteges/PNACTG973V5001IW/detail/mana/foret-de-sables-blancs-de-mana*

B.3 Forests (montane forest non-included)

Habitat and species description

Tropical forests cover **87% of the territory**, among which 60% are considered as primary forests, yet most of its ancient soils are infertile (FAO,2015). In Guyana, the tropical lowland rainforest gathers most of the forest cover, and include interior alluvial plains and low-lying lands, mixed forests and dry evergreen forests **(>55% of Guyana's forests).**

Forest type	Area (%)
Rainforest	36
Montane	35
Swamp & Marsh	15
Dry Evergreen	7
Seasonal	6
Mangrove	1
Total	**100.0**
Source: ITTO, 2005 and Guyana Forestry Commission, 2012.	

Table 1 Area covered by different forest type. Source: ITTO, 2005

Lowland rainforests have **high primary productivity**, particularly due to their closed and dense canopy, which maintains a warm and humid microclimate with low to moderate diurnal and seasonal temperature variations. Those conditions support a **high functional and taxonomic diversity**, visible through the high leaf area index, thanks to the indigenous energy source which allows the high **plant diversity** (foothills, epiphytes, lianas, ferns) all of which are suitable habitats for the development of living organisms. The canopy is evergreen and multi-layered, particularly due to the **vertical stratification of the food webs.** Nutrient capital is either sequestered in the vegetation or recycled through a layer of litter, which retains nutrients. Birds and mammals then play a crucial role in dispersal and pollination.

As regard species, the forested areas are rich with plant endemism. To date, forests are inhabited by 1,260 species of amphibians, birds, mammals, and reptiles, and over 8000 plant species (*Nb: those data include montane forests).* According to the IUCN Red List reference, **among the 184 species at risk (CR, EN, VU), 71 lives in the forest (38.5%)**. Among the 5 CR species living in the forest, there is **3 plants and 2 birds (*Cercomacra carbonaria* and *Synallaxis kollari*).** Finally, a collaboration between GEF, UNCBD, UNEP, & UNDP (2018) shows that Guyana's forest hosts a high percentage of threatened species especially in forest ecosystems and in the white sand plateau (Figure 11)

Tropical Lowland Forests' Characteristic Traits

- **Forest along the Essequibo alluvial plain:** The Essequibo River is connected to the Amazon Basin and holds therefore a great number of sediments. It is the largest river in Guyana, and the largest river between the Amazon and the Orinoco River with a drainage basin of 151,000 square kilometers and its 20-kilometre-wide estuary.
- **Niche refugia** for many globally endangered faunal species such as the Giant River Otter *(Pteronura brasiliensis)* and Tapir (*Tapirus terrestris*), both of which are also officially gazetted as locally threatened species.
- **The Guyana Lowland Floristic Province:** Owing to its vegetation, a significant southern forested area is known as the transverse dry belt and is characterized by semi-open forests, patches of savannah, and dense mesophilic forests on higher elevations as well as beside rivers and streams (Northern South America: Guyana, Suriname, French Guiana, northern Brazil, and eastern Venezuela ecoregion).
- **Endemic timber species** such as Greenheart (*Chlorocardium rodiei*), Purpleheart (*Peltogyne venosa*), Wamara (*Swartzia leiocalycina*) and Clump Wallaba *(Dicymbe altosonii*), the critically

endangered Sareberebalii *(Vouacapoua americana*), the endangered Silverballi (*Aniba rosaedora*).

Ecosystem services, interest for global biodiversity

- **Carbon storage:** as forests of Guyana stores about 5 gigatons CO_2 equivalent in its above ground biomass (GEA, 2019[21])
- **Timber and non-timber forest products,** especially for indigenous communities
- **Protection of watersheds,** carbon sequestration
- **Non-use value,** in the hinterland of Guyana, indigenous communities living there benefit from social and cultural services derived from these areas.
- The **aesthetics of the environment** provide a good attraction for ecotourism and other forms of nature-based tourism

Studies on tropical low land forests

There are very **few studies focusing on Guyana's forest only**. The best specific data are the one of FAO and national reports. Hout's work is the most famous one to be done in Guyana. There is other papers studying the regional scale.

- FAO, Global Forest Resources Assessment: Guyana. Rome: Food and Agriculture Organization of the United Nations, 2020
- FAO, State of the World's Forests 2020
- Van der Hout, Resource Assessment and Forest Management Plan for the CITES-Listed Species *Cedrela odorata* In Guyana, 2016.
- Van der Hout, Testing the applicability of reduced impact logging in greenheart forest in Guyana, 2000
- Kalamandeen et al., Pervasive rise of small-scale deforestation in Amazonia, 2018

Protection status and vulnerability

Most of Guyana's forest cover has been designated as **production forest**, with 84.6% being publicly owned by the State and the remaining 15.4% either declared as indigenous lands or privately-owned lands. 8.7% of the territory is protected with 5 protected areas among which 3 are part of the lowland rainforest ecosystem, being the following, from the smallest to the biggest, corresponding also to the northernmost to the southernmost (Protected Area Trust, consulted in 2021):

- **Kaieteur National Park (Ib category),** created in 1929 in the Potaro-Siparuni Region: Covering 62 700 hectares, this area hosts endemic species like the Golden Frog (*Anomaloglossus beebei*) and a recently discovered blue tarantula and the Kaieteur Falls with its single drop of 226 metres (741 ft), which is over four times higher than Niagara Falls. It is home to the Patamona people. 1,100 species have been documented by Iwokrama.
- **Iwokrama Forest (VI category):** Covering 371,000 hectares of rainforest (1.6% of Guyana's landmass and 2% of Guyana forests), the Iwokrama International Centre (IIC) was established in 1996 under a joint mandate from the Government of Guyana and the Commonwealth Secretariat to manage the Iwokrama forest (Iwokrama Act, 1996). The center documented a total of 1,556 plant species in the protected area, and hosts the red howler monkey, the red-and-green macaw, the Guianan cock-of-the-rock, the black caiman, and the black spider monkey
- **Konashen Amerindian Protected Area (VI category),** created in 2017 in the Upper Takatu-Upper Essequibo Region: Covering about 3% of the country's land area (625,000 hectares), it is home to the Wai Wai people and the only indigenous-owned territory in the protected area system. In terms of species, it hosts the Harpy Eagle (*Harpia harpyja* – NT). Iwokrama has documented an estimated 2,700 plant species in the park, which is the highest concentration of species compared to other the others national parks.

[21] *https://gea.gov.gy/wp-content/uploads/2019/07/A3-Sustainable-Management-of-Natural-Resources.pdf*

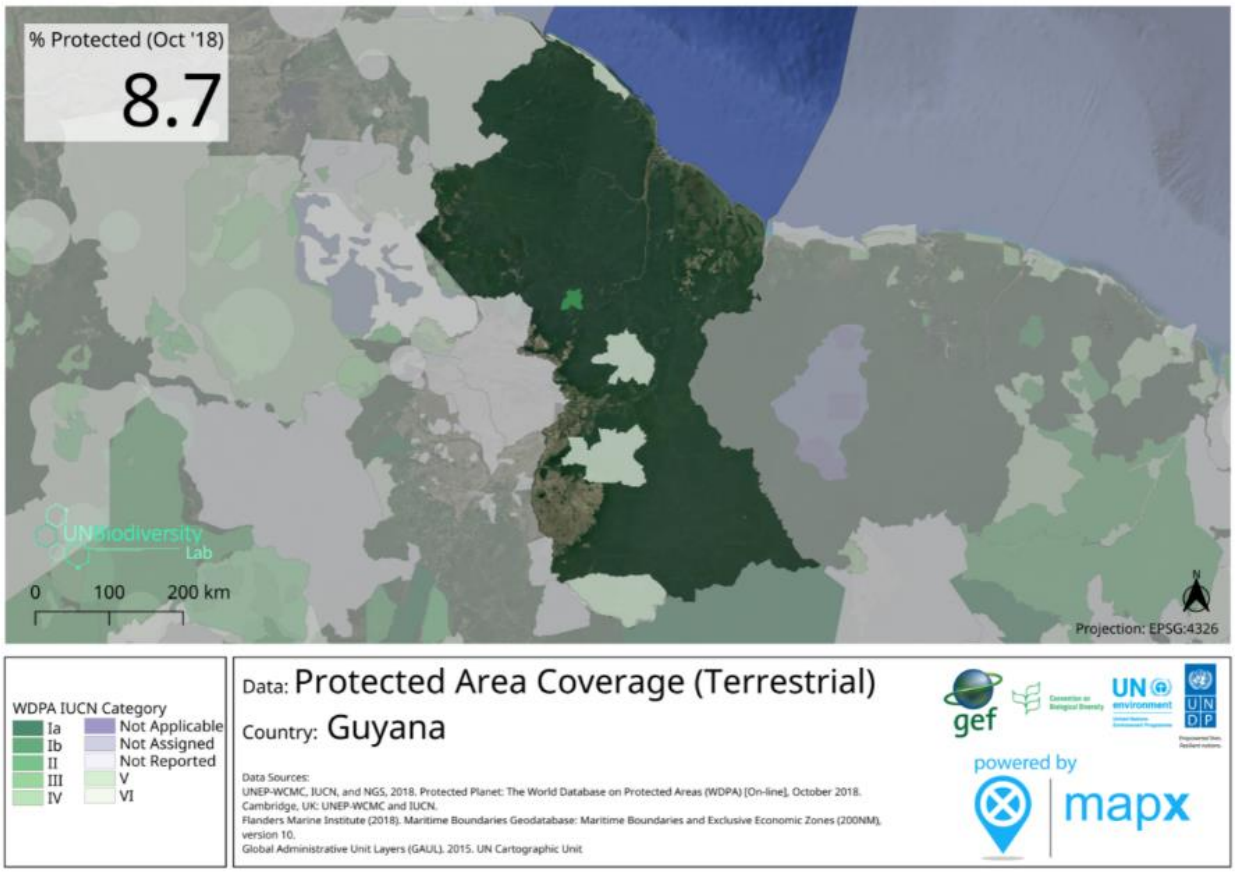


Figure 12 Protected area coverage (terrestrial). Source : GEF, UNCBD, UNEP, & UNDP, 2018

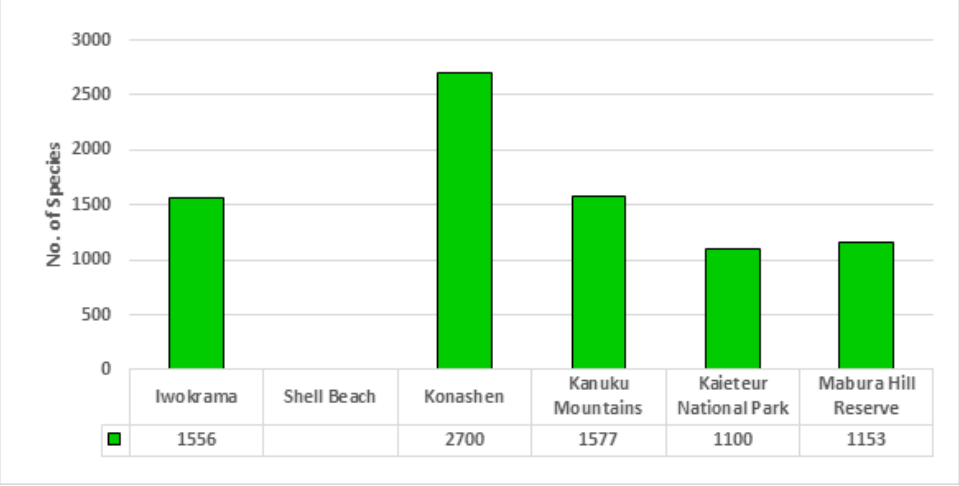


Figure 13 Number of species found in various biologically important areas in Guyana. Source: S.Hamer, 2021

Moreover, a specialized fund, the **Guyana REDD+ Investment Fund (GRIF)** was created in 2010 following a 2009 Memorandum of Understanding between the Governments of Guyana and Norway as a means to channel international financing for **avoided deforestation**. The IADB acts as the GRIF trustee, and as of 2014, it had received USD 150 million in payments from Norway[22]. This reward system is another element that confirm that the forest ecosystem is relatively well preserved in Guyana.

Forest ecosystem isn't considered as vulnerable in Guyana, as long as anthropic intrusion remains punctual, forests integrity being essential for global biodiversity.

Criteria of importance for the ecosystem

Endemism	Very high
Richness	Very high with great functional and taxonomic diversity due to the productivity of the ecosystem
Connectivity	High with few anthropic intrusion
Climate change	Very high carbon storage potential due to evergreen forests

B.4 Highlands, mountains, plateaus

Habitat and species description

Mountain forest ecosystem represent **35% of the country's forests** (International Tropical Timber Organization) and include lowland and lower montane forests on brown and white sands, dry sub montane forests, montane forests, and upper montane forests.

Mountain forests grows under a **permanent humidity mesoclimate** with frequent mists, due to the orographic uplift and shady conditions and to the closed tree canopy. **Productivity is limited by cool temperatures, higher exposure to UV-B and wind** and by the fact that soils are sometimes shallow. Propagules are dispersed by wind, birds and territorial mammals and in terms of flora, epiphytic ferns, bryophytes, lichens, orchids, bromeliads drape the branches and exploit the atmospheric humidity.

In **submontane forests of the Pakaraima region, (500-1500m),** dominant species are *Dicymbe, Licania, Eschweilera, Mora, Alexa*, and this ecosystem host the **highest level of plant endemism** in the country, followed by the upper Mazaruni-Kako-Roraima (GoG, 2019). In **upper montane forests (1500-2000m),** on the high table mountains (Mounts Roraima, Ayanganna and Wokomung), dominant species are *Bonnetia tepuiensis, Schefflera, Podocarpus, Magnolia and Weinmannia*, as well as *Melastomataceae, Rubiaceae, Ilex* and *Podocarpus steyermarkii*. In **submontane forest of the Acarai Mounts from, 600-800 m**, the forest is quite similar to the forest in the Kanuku Mts. with *Centrolobium, Cordia, Peltogyne, Vitex, Inga, Protium, Tetragastris, Parkia, Pseudopiptadenia, Spondias* and *Genipa*. Forests on the mountain tops are dominated by *Myrtaceae* and *Clusia* on Sierra do Acarai.

Two **geological forms are typical to the Guiana Shield** landscape:

- **Tepuis (tabular landforms),** which are in the center-west of Guyana are the *"house of gods"* (Pemón Amerindian word for tepuis). In Guyana, the Akawaio ethnic group uses the term "tipu". Their altitude reaches 3,000 meters for the Sierra de la Neblina in Venezuela. These summits are relics of a peneplain called Auyan, which has been **isolated by erosion** (Briceño & Schubert, 1990). Average rainfall is abundant and generally exceeds 2,500 mm per year (Maguire 1970). These assembled formations contain a discontinuous surface area of about 5,000 km² (Huber,

[22] *http://www.guyanareddfund.org*

1995) but constitute one of the best studied ecosystems in the region. The dominant vegetation is Mimosoideae and Burseraceae and the endemism exceeds a thousand species (for Guyana and Venezuela).

- **Inselbergs** (also found in Africa): From an ecological point of view, it is problematic to consider inselbergs in the mountains because they are referring to a type of bedrock. These isolated domes or rock peaks derive their names from their island characteristic emerging from the forest, literally *"island mountain "* in German[23]. Generally, the inselbergs are gr**anitic, most of them are dated around 2,100 Ma.** They are a **dry habitat** where temperatures can exceed 50°C during the dry season. Bare rock supports cyanobacteria, the first stage of colonization with alteration of rock and organic matter input (Sarthou 1992). The vegetation presents often xerophytic characters often with shrubby islets. The most represented families are Poaceae, Orchidaceae, Bromeliaceae, Eriocaulaceae, Lentibulariaceae and Xyridaceae.

As regard species, **taxonomic diversity is moderate but local endemism is very high especially at high altitudes**, where the greatest concentration of rare and endemic species can be found, the most relevant example being the recently discovered Roraima mouse (*Podoxymys roraimae*).

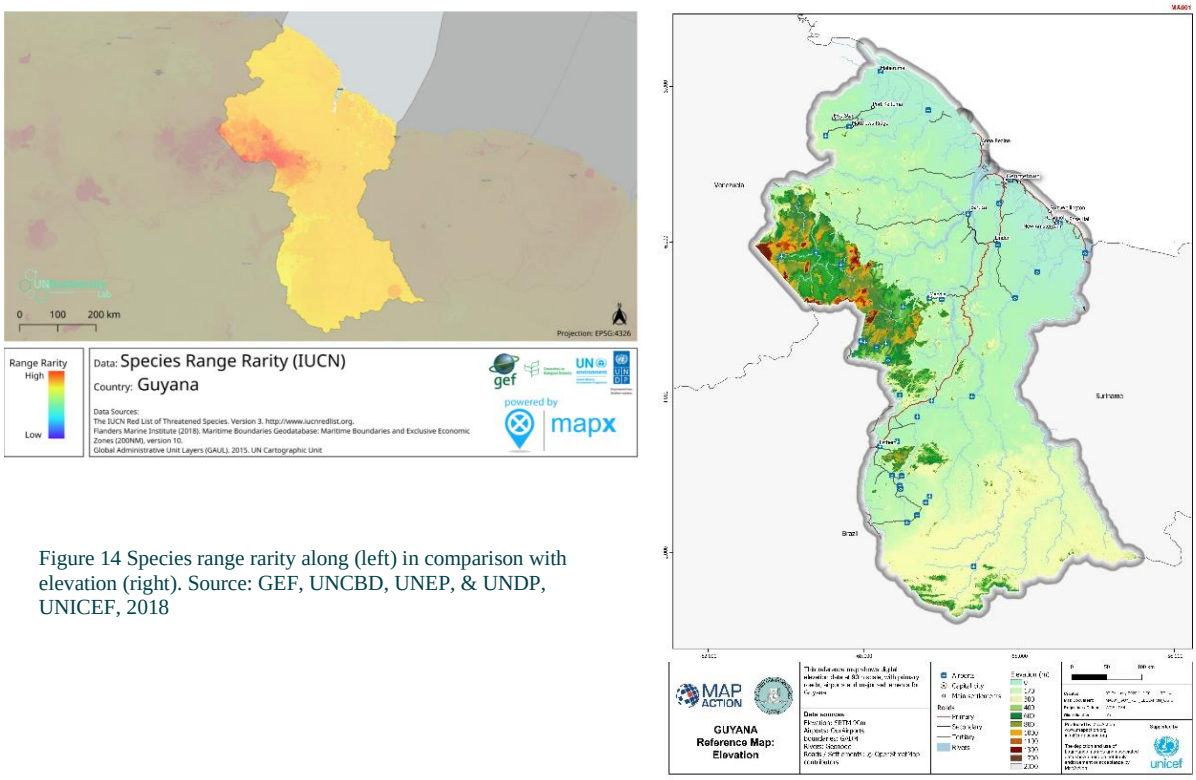


Figure 14 Species range rarity along (left) in comparison with elevation (right). Source: GEF, UNCBD, UNEP, & UNDP, UNICEF, 2018

Highlands, Mountains and Plateaus Characteristic Traits

- **Tepuis and endemic rare species** are remarkable tabular sandstone mountains which rise steeply above the savannahs and tropical forests. Their prolonged isolation and an abrupt topography have led to a unique habitat with many endemic plant and animal species, the latest example being the discovery of the Roraima mouse (*Podoxymys roraimae*) at the top of Wei-Assipu tepuis (2216m high) in 2009. The mouse belongs to one of the rarest mammal species, but also to the most restricted geographical distribution: until then, only six specimens had been collected in 1927 and 1989, all from the summit of the same tepui, Mount Roraima (Kok et al., 2015[24]).

23 This name was given by a German geographer Walter Bornhardt who worked in East Africa (Bornhardt, 1900).
24 Evolutionary affinities of the 'Lost World' mouse suggest a late Pliocene connection between the Guiana and Brazilian shields https://onlinelibrary.wiley.com/doi/abs/10.1111/jbi.12461

- **Inselbergs:** due to their extreme soil conditions are home to a very high proportion of protected or rare protected or rare species. This ecosystem hosts a xerophytic flora in the middle of a dense rainforest. Bromeliads, orchids and Clusiaceae constitute the three families that generated the most endemic species in these environments. They are usually isolated “insular” structures under edaphic, floristic, and microclimatic aspects and are suitable models for studying questions of island ecology.
- **Vulnerability to climate change:** Altitudinal gradients in temperature, precipitation and exposure are pivotal in ecosystem structure and function, which makes it vulnerable to climate change.

Ecosystem services, interest for global biodiversity

- **Refuge zone** during dry phases
- **Ecological discontinuous corridors**

Studies on mountains ecosystems

- Kok et al., Evolutionary affinities of the ‘Lost World’ mouse suggest a late Pliocene connection between the Guiana and Brazilian shields, 2015
- Barthlott et al., Phytogeography and vegetation of tropical inselbergs, 1993
- Huber, The Chimanta Massif, Guyana Shield, Venezuela. A Tepuyan Ecological Essay, 1992
- Huber, Diversity and vegetation in the Guyana Region: An overview, 2005
- Campbell & Hammond, Floristic inventory of tropical countries, 1989

Protection status and vulnerability

The Kanuku Mountains protected area, was created in 2011 in the Upper Takatu-Upper Essequibo Region, covers 611 000 hectares and is home to the Macushi and Wapishana people, who have traditionally depended on the ecosystem for food, water, shelter and medicines, and are integrated in the area governance. Yupukari, Wapishana, and Macushi indigenous groups take the lead in conservation, which is managed through the Kanuku Mountains Regional Council, established to help oversee conservation in the 21 communities throughout the Kanukus[25]. On those mountains, 1 577 species have been documented by Iwokrama. The area hosts **the highest recorded bat diversity** in the world with 89 species. Guyana and Guiana Shield species also mix with endangered Amazonian “giants”, including the Giant River Otter (*Pteronura brasiliensis,* EN), Harpy Eagle (*Harpia harpyja*, NT), Giant Anteater (*Myrmecophaga tridactyla,* VU), Black Caiman (*Melanosuchus niger)* and Giant River Turtle (*Podocnemis expansa*). It also hosts the dwarf caiman (*Paleosuchus trigonatus*) which is among the smallest species of crocodilians, the *Podocnemis unifilis* (VU).

In mountains ecosystem, the connectivity is still high (figure 15) and the major the source of vulnerability is mainly coming from climate change’s perspectives.

[25] *https://news.mongabay.com/2019/01/a-community-in-guyana-relies-on-indigenous-knowledge-in-conservation/*

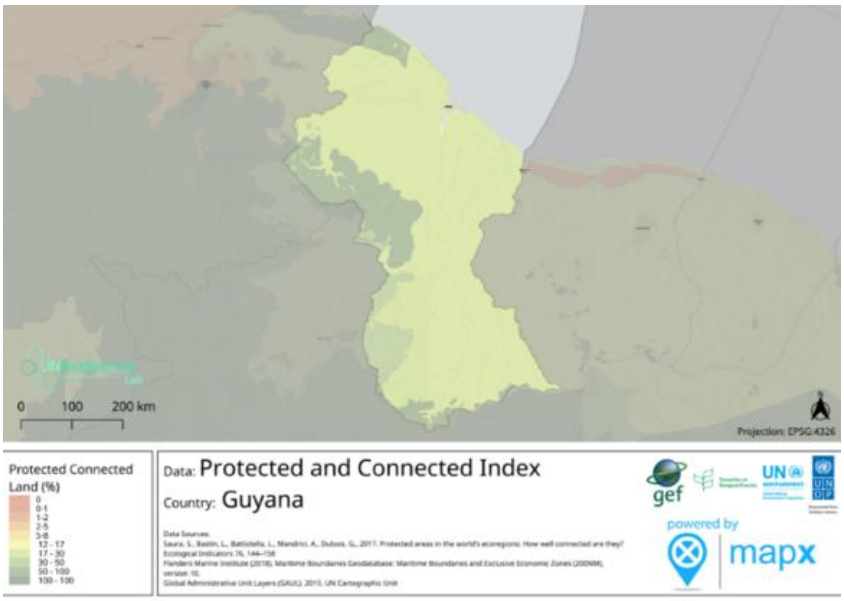


Figure 15 Results of the Protected Connected (ProtConn) index for Guyana.

Montane ecosystem isn't considered as vulnerable in Guyana because it is hardly accessible and relatively well protected. Though, it hosts the highest concentration of endemism in the country.

Criteria of importance for the ecosystem

Endemism	Very high especially at high altitudes
Richness	Moderate
Connectivity	Very high
Climate change	Vulnerability to climate change

B.5 Savannas

Habitat and species description

Interior savannahs represent **8% of Guyana's territory** and are scattered throughout the territory. The main vegetation is shrublands (at low levels) and grasslands (at altitudinal levels), the elevation is mostly 100-120m (lowlands), with abruptly elevating altitudes of 610m to 990m (highlands).

- **The lowlands savannas** are located on the white sand plateau. There are dry savannas known as muri scrub.
- **The Pakaraima Mountains** of north-west Guyana occurs on some plateaus between 600-1,200 m in the upper Mazaruni. It is the only upland savannah known in the Guiana Shield.
- **Northern shrub savannahs** form an interrupted chain stretching from Guyana into Suriname and are heavily degraded by human activities.
- **The Rupununi savannahs,** in the southern part of Guyana, are shrub savannah with woody elements (*Curatella americana* and *Byrsomima crassifolia)* mixed with open areas dominated by grass (*Trachypogon sp.)* with the presence of meadows (non-grass species) associated growing on highly acidic substrates such as sandy soils on white sands (broadleaf meadows) in flooded conditions. Those savannas form large alluvial plains **crossed by rivers and riparian forests** and are exposed to annual dry season fires. The six major rivers (Essequibo, Rewa, Siparuni,

Takutu, Burro-Burro and Rupununi Rivers) passing through the Rupununi and this hydrological regime has influenced Guyana's species richness and diversity and its landscapes over geologic time. It is also part of the Gran Savannah Venezuela, which is one of the two great ecosystems of savannas in Latin America (along with the Brazilian Cerado).

Fires and herbivory are crucial as those factors maintain the structure of the savannah. They are the main agent that limits tree dominance and maintains tree-grass coexistence in those pyric savannas. This phenomenon explains the **resilience of the environment** and can be seen through plant traits that tolerate seasonal drought (deciduous leaf phenology, subterranean storage organs and deep roots). Soils are moderately to poorly fertile and local endemism is fairly low, but the vegetation dynamics are very complex, which makes it exceptional.

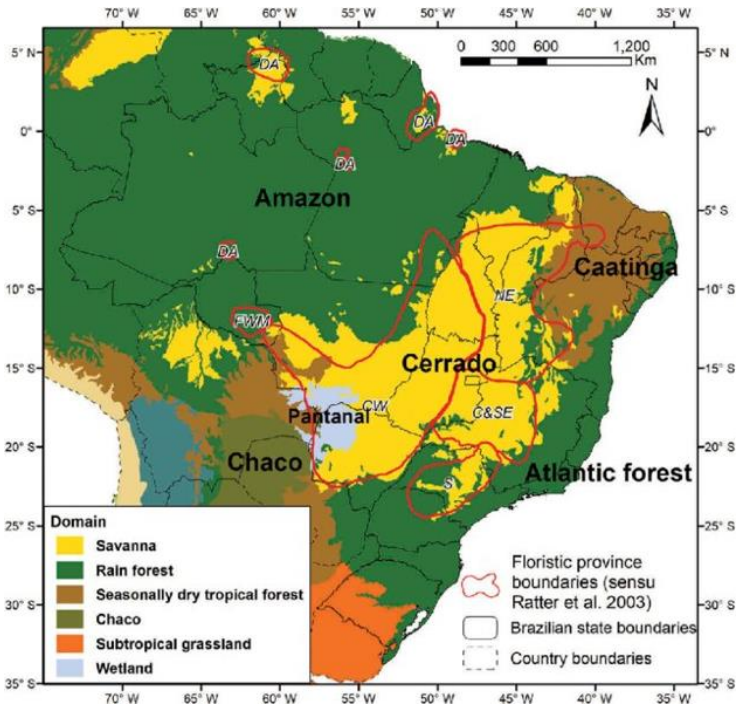


Figure 16 Map of the major biogeographic domains of South America, showing the Brazilian Cerrado and its boundaries. Source: Vieira et al., 2019.

The six Cerrado floristic provinces (Ratter et al. 2003) shown are: Central and South-eastern (C & SE), Central-Western (CW), Disjunct Amazonian Savannas (DA), Far Western Mesotrophic Sites (FWM), North-eastern (NE), and Southern (S). Map based on Olson et al. (2001).

The Savannas' Characteristic Traits

- **Subtle equilibrium with disruptive gradient (frequency/intensity of fire):** as described below fire is both necessary and threatening to maintain the ecosystem.
- **The Rupununi savannah:** is a flooded savanna hosting gallery forests, wetlands, bush islands and rocky outcrops (WWF, 2016). The region provides water connectivity between the ancient Guyana Shield and the Amazon basin and host more than 450 fish species. the value of conserving connectivity of this habitat is proved very high (De souza, 2020).
- **Coastal savannahs:** Also called the intermediate savannah, are easily accessible, which is relatively rare.

Ecosystem services, interest for global biodiversity

- **Refuge zone and migration of species**: The flow of savannahs floodwaters (seasonal system) generates a migration of micro and macrofaunal associated with this dynamic ecosystem. It facilitates the inter-breeding of Amazonian species with species from the Guiana Shiel (GoG, 2019), thereby enhancing genetic pools and biodiversity.
- **Provide clean water:** especially wetland, flooded savannas, which absorb, filter and store enormous amounts of water during the rainy season. The Rupununi River which has its source in

the Kanuku Mountains and other tributaries of the Essequibo River, greatly influence the hydrology of the savannahs.

- **Provide material for everyday use and medicine:** firewood, timber for fences posts, houses, canoes, raw materials to make baskets, sifters, furniture, jugs and other household items (*Heteropsis spp, Manilkara bidentata*), medicines as crabwood tree (*Carapa guianensis)*

Studies on savanna ecosystems

- Biodiversity of the Southern Rupununi Savannah, WWF, 2016
- De Souza et al., Connectivity of neotropical river basins in the Central Guiana Shield Based on Fish Distributions. Frontiers in Forests and Global Change, Volume 3, 2020

Protection status and vulnerability

There is no current direct approved protection status on Savannah lands, however, a large part of the southern savannahs is in **indigenous territory**, which is a guarantee of protection. Several initiatives coming from conservation NGO (especially the WWF-Guianas), aims to register flooded savannas as Ramsar sites, but no action is yet taken at higher levels of decisions. Nowadays, even if well-known for its resilience, the ecosystem is **one of the most vulnerable in Guyana**. The last CBD National Biodiversity Report on Guyana showed that natural event highly affects savanna, and that the **highest rate of degradation among Guyanese ecoregions was in the savannah ecosystem**. This ecosystem is considered as fragile, ecological important and probably best suited for both biological conservation and high value-low impact economic activities such as ecotourism.

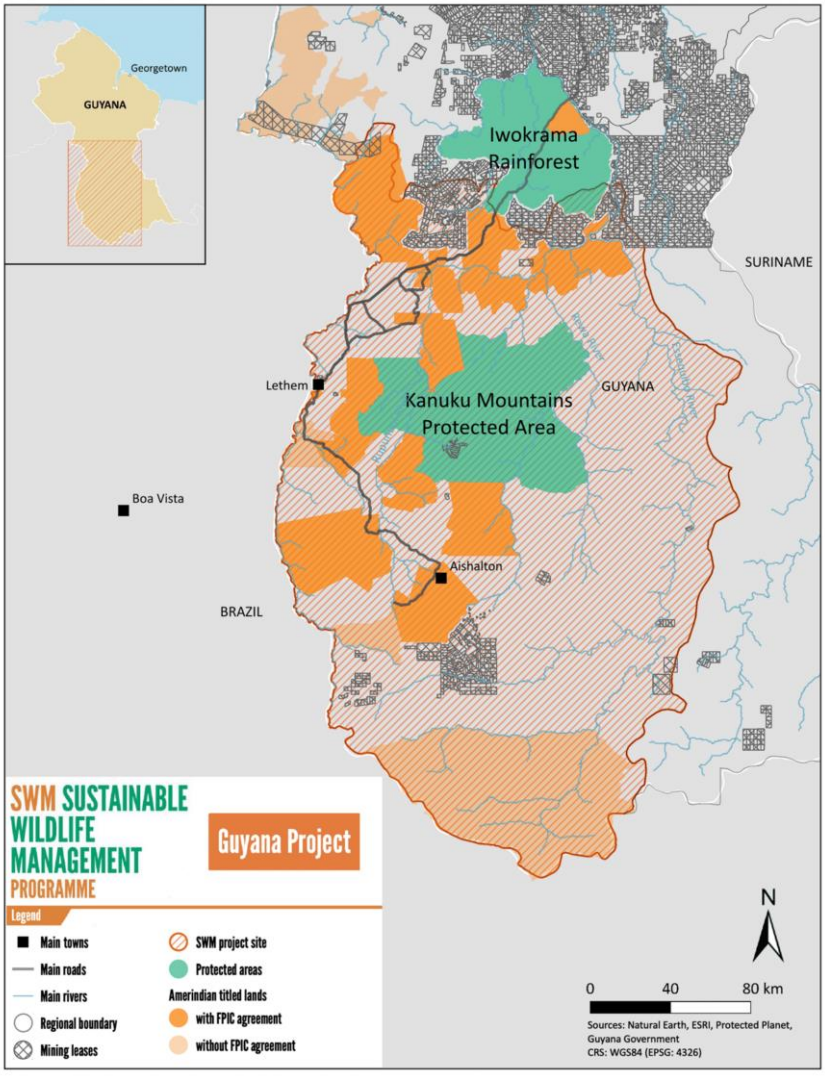


Figure 17 Status protection of the southern savannahs. Source: SWM project

Savannahs are considered as vulnerable due to the rising anthropic pressure, coming from various activities, and leading the degradation of the ecosystem.

Criteria of importance for the ecosystem

Endemism	High with a wide variety of savannahs
Richness	Moderate
Connectivity	Very high, with a complex system that is to better understand and to preserve
Climate change	Few studies but potentially

B.6 Freshwater Ecosystem

Habitat and species description

The Guiana Shield region contains approximately **10 to 15% of the world's freshwater volume** and waters have been clue in the country's structuration. The region's name 'Guianas' originated from an Amerindian term for 'land of many waters', reflecting the vast water system made up of wetlands, streams and rivers.

Guyana comprises **three freshwater eco-regions** (Orinoco Delta and coastal drainages, Essequibo, Guianas). Of particular importance is the Essequibo ecoregion, which serves as an important biological corridor that is connected to the Amazon Basin. This link allows for a continuous expanse of water during the wet seasons between the tributaries of Rio Branco, Brazil, and the Rupununi River (GoG, 2015). The internal network of waterways (rivers, creeks) occupies about 18,120 km^2 or 8.4 percent of the country's land area (GoG, 2019) and include three main rivers drain from the south of Guyana into the Atlantic Ocean which is to the north of the country (FAO, 2015; US Engineer Corp, 1998):

- **The Essequibo River,** the largest (1,014Km) which draining a total estimated area of 140,637 Km^2.
- **The Berbice River,** the second largest (595km) which drains an area of 5,102 km^2.
- **The Demerara River,** the smallest (346 km) and drains an area of 4,040 km^2

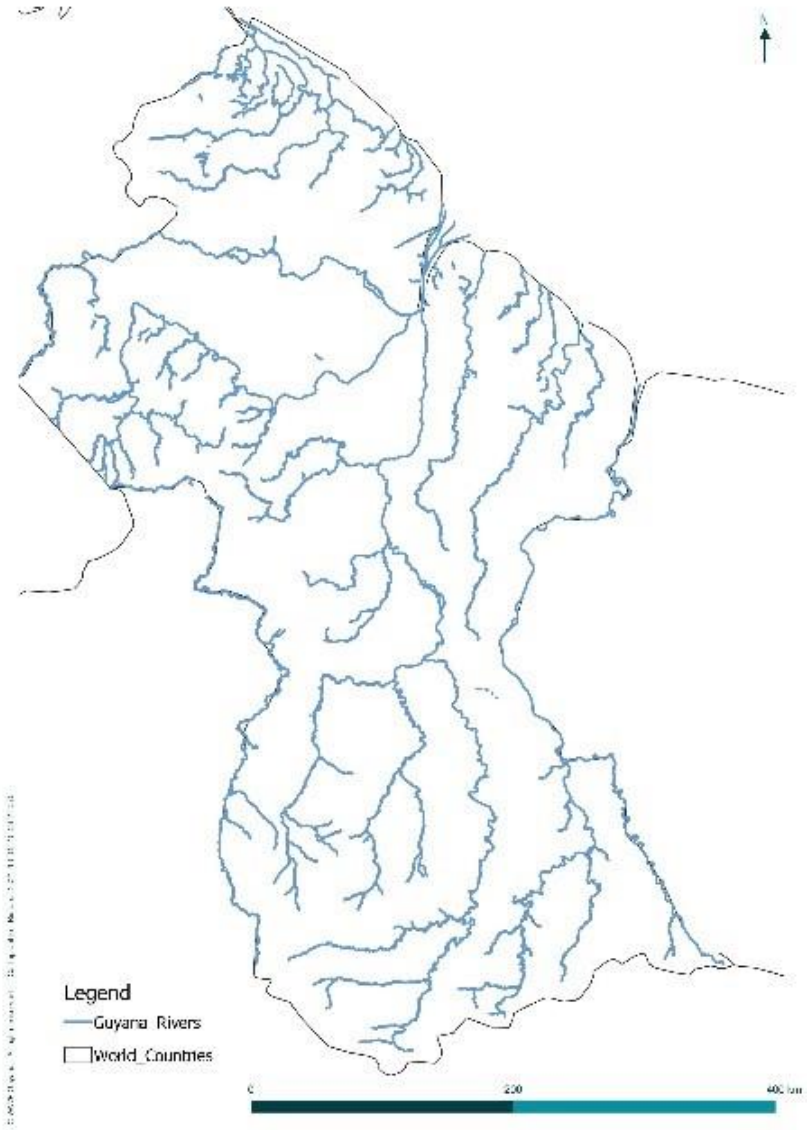


Figure 18 Main rivers of Guyana. Source: GLSC, 2021

A WWF-Guianas study (2012) identified and characterized **23 wetlands** sites which are the followings

Lake Mainstay, Essequibo Coast	Assakata Lake and wetlands, North West District-NWD
Lake Tapakuma, Essequibo Coast	Baramani Lake, NWD
Lake Capoey, Essequibo Coast	Almond Beach, NWD
Lake Mashabo, Essequibo Coast	George, NWD
Surama Pond, North Rupununi	Arnold Ponds, NWD
Airstrip Pond, North Rupununi	East Demerara Water Conservancy
Oma Pond, North Rupununi	Mahaica-Mahaicony-Abary Conservancy
Devil Pond, North Rupununi	Manarabisi Swamp, Corentyne
Grass Pond, North Rupununi	Sandaca Swamp, Corentyne
Shulinab, South-central Rupununi	Guysuco Conservancy, Corentyne
Sandcreek, South-central Rupununi	Halcrow Conservancy, Corentyne
Moruca Swamp, Moruca Sub-district	

The water system contains many **ecological niches**, resulting in a high local zonation of vegetation and a high diversity of habitats at the plot level. These wetlands are rich in **autotrophic species** (phytoplankton, algal mats and epiphytes, floating and amphibious grasses and graminoids, semi-

terrestrial woody plants) which are functionally **diverse and productive**. They support complex food webs including zooplankton, aquatic invertebrates, fish, amphibians, reptiles, aquatic mammals, aquatic birds and terrestrial animals with diverse feeding strategies. Water systems are quite remarkable for their **connectivity**, their functional and structural value and their **scientific importance** due to the number of microorganisms that are essential to the maintenance of rivers ecosystems itself and the entire forest it waters.

In terms of species, endemicity is high hosting at least **476 freshwater fish species** of which about 83 species are considered endemic (17.5%). Water systems hosts high abundance and diversity of invertebrates (some with dormant traits that allow them to persist during drought phases), waterbirds, reptiles and mammals, whose reproduction and recruitment, particularly of fish, coincide with the availability of food induced by flooding regimes, which are in turn determined by river flow regimes (seasonal precipitation and catchment melting). Those rivers also host **high micro-endemicity**. In Guyana's waters, there are also endangered species, 7 species of marine mammals (6 cetaceans and 1 manatee species), 4 turtle species and 2 sawfish species. The freshwater ecosystem also accommodates amphibians. An estimate 27% of all amphibian species are endemic (37 of the 137 documented species of frogs and toads) (Cole et al., 2012)[26]. Approximately 28 amphibian species are listed as endangered in Guyana (Living National Treasures, 2018; Cole et al., 2012).

Freshwater Ecosystem Characteristics (not specific to Guyana)

- **High connectivity** with complex food webs that research is trying to assess (Ruiz Ramos et al., 2020[27])
- **Special habitat** with endemic species and micro-endemicity
- **Importance of Essequibo waters** as a biological corridor that connect to the Amazon Basin. The Essequibo River forms a continuous expanse of water during the wet seasons between the tributaries of the Rio Branco in Brazil and the Rupununi River in Guyana[28]

Ecosystem services, interest for global biodiversity

- **Refuge zone** during dry seasons, feeding grounds and migratory routes
- These wetlands provide **regulatory, provisioning, and cultural services**, helping to recharge groundwater supplies, and serve as a source of irrigation water for the entire terrestrial ecosystems.

Studies on freshwater ecosystem

There aren't specific studies on freshwaters in Guyana, but studies highlight the impact of invasive species in freshwaters.

- Toft et al., The effects of introduced water hyacinth on habitat structure invertebrate assemblages and fish diets, 2003
- Villamagna et al., Ecological and scoio-economic impacts of invasive water hyacinth (Eichhornia crassipes): a review, 2010

Protection status and vulnerability

There **isn't specific protection status** on freshwaters in Guyana, but WWF launched in August 2021 the **"Sweet Water Campaign Website"** to explain the urgent need for freshwater protection, focusing on the South Rupununi. The final stages of the awareness campaign aim to engage government and other key stakeholders in high-level discussions with the aim of securing a commitment to developing new policies and regulations towards the protection and maintenance of sensitive areas where water flows. Guyana is also to become a signatory to the **RAMSAR Convention for protection of wetland (GoG, 2019).**

---

[26] *Cole, C. J., Townsend, C. R., Reynolds, R. P., MacCulloch, R. D., & Lathrop, A. (2012). Amphibians and reptiles of Guyana, South America: illustrated keys, annotated species accounts, and a biogeographic synopsis. Proceedings of the Biological Society of Washington, 125(4), 317–578. https://doi.org/10.2988/0006-324X-125.4.317*

[27] *https://ieeexplore.ieee.org/document/9358961*

[28] *Watkins, G., Saul, W., Holm, E., Watson, C., Arjoon, D. and J. Bicknell, 2004. The Fish Fauna of the Iwokrama Forest. Proceedings of the Academy of Natural Sciences of Philadelphia. Vol. 154, pp. 39-53*

The relative abundance of freshwaters doesn't make this system vulnerable in Guyana. However, as the source of any life, it can be considered as vulnerable, and as a priority to conserve.

Criteria of importance for the ecosystem

Endemism	Very high
Richness	Very high
Connectivity	Very high
Climate change	Will be crucial for the resilience of ecosystems

B.7 Marine ecosystem

Habitat and species description

The marine environment is divided into coast (marine shelf biome) and deep sea (pelagic marine biome). The continental slope of the Guiana Shelf is **increasingly highlighted in studies,** particularly following the studies carried out by oil companies on the Guiana Shelf over the last ten years. This littoral fringe with mudded waters is loaded with sediments, coming from the alluvium of the Amazon, which enrich marine habitat with nutrient and attract many species (sea turtles in Shell Beach for instance).

Beyond this fringe, clearer waters host pelagic animals, that comes to feed in this loaded fringe. There is a very special area called the North Brazil Large Marine Ecosystem, and it is an oceanic habitat that extends from the Caribbean Sea south to the Parnaiba River in Brazil. Seagrass and coral reefs that normally occurs in the tropical Atlantic coastal region does not occur in Guyana due to the presence of a **high density of clay** particles that is continuously spit of by the Amazon River which originates from the South American Highlands. The clay particles cause the turbidity of the nearshore waters of Guyana to be dry high which is not conducive to the growth of seagrass and corals. However, **deep-water corals do occur offshore Guyana (**ERM et al., 2020)[29]. Deepwater corals are actually a collection of animals that build one common skeleton and can be found as shallow as 46m to more than 3000m in depth (NOAA, 2021[30]).

The pelagic marine biome is subdivided in different layers (epipelagic, mesopelagic, bathypelagic and abyssal waters) which are highly connected and play a crucial role in **maintaining the global climate**. Indigenous productivity in the epipelagic layer of the ocean accounts for about half of all global carbon fixation. This activity in turn supports a **complex food web** and a high biomass of diatoms, copepods (resident and vertical migrants), fish, cephalopods, marine mammals and seabirds, including any predators visible taking advantage of the high light environment. The lower zone, the mesopelagic waters, is called 'twilight' because it receives enough light to discern the diurnal cycles but too little to ensure photosynthesis. In the two lowest layers, the bathypelagic and then the abyssal waters, there is no light, and the energy sources are allochthonous, coming mainly from the deposition of particulate organic matter (organic fluxes and detrital falls) from the epipelagic horizon - the flux of which decreases through the mesopelagic and then the bathypelagic zone until it reaches the abyssal plains. Thus only 0.5-2% of primary production in the epipelagic zone reaches the abyssal seabed, but population persistence in the deep sea is largely dependent on connectivity between different communities (Sammarco et al., 2004, Atchison et al., 2008). **Any change in the natural dynamics of epipelagic waters has implications for the abyssal floor and the ability of species to perform functions** (respiration, bioturbation) that modulate many of the ecosystem services provided by the abyssal plains, including nutrient regeneration and carbon sequestration.

[29] *ERM, GSEC, & EMC. (2020). Environmental Impact Assessment Liza Phase 1 Development Project Esso Exploration and Production Guyana, Limited: Vol. III (Issue July). www.erm.com*
[30] *NOAA. (2021). Deep-Sea Coral Habitat . NOAA Fisheries. https://www.fisheries.noaa.gov/national/habitat-conservation/deep-sea-coral-habitat*

In terms of species, the great stakes on the continental slope are marine turtles with nesting beaches of marine turtles and two emblematic mammals (the sotalie and the lamentin). This sediment-laden strip is also rich in shrimp and teems with species in terms of biodiversity and biomass. In the deep ocean, a high density of cetaceans is known to occur including the Guiana Dolphin (*Sotalia guianensis*), the West Indian manatee (*Trichechus manatus*), the Sei Whale (*Balaenoptera borealis*), the Blue Whale (*Balaenoptera musculus*), the Sperm Whale (*Physeter macrocephalus*) and the Fin Whale (*Balaenoptera physalus*).

Marine Ecosystem Characteristic traits (which are the one of Guiana Shield and the entire oceans)

- **Muddy circulation and swells of the Atlantic:** The 1,500 km coast of the Guiana Shield is characterized by those two important large-scale elements, sediments from large rivers constitute a major structuring factor for the estuarine, coastal, and shelf marine ecosystems.
- **Coral adaptation to turbid waters:** sediment-induced stresses in corals in those specific waters created some mechanisms of adaptation or acclimatize to variable sedimentation and turbidity (Anthony et al., 2002)
- **A major shift** around the 30 m isobath between a coastal and offshore ecosystem (Willems, 2018).
- **High sensitivity to climate change**
- **High connection** of the pelagic ocean

Ecosystem services, interest for global biodiversity

- **Resource:** supply of fishes and marine nutrients
- **Climate regulation** in name of the biggest carbon stock on earth.

Studies on marine ecosystem

The marine ecosystem in Guyana was not extensively studied in the past. However, **since the commencement of oil and gas development, there has been a few studies done with the most detailed study being conducted by Esso Exploration and Production Guyana Limited (EEPGL) as part of their environmental impact assessment (ERM et al., 2020).** The dataset was put together over a three-year period (2017-2019). There are studies that have been conducted as recently as 2021 by NGOs such as World Wildlife Fund (WWF) which completed a bassline assessment as part of the EU funded Marine Spatial Planning project titled, “Promoting Integrated Ocean and Participatory governance in Guyana and Suriname: The Eastern Gate to the Caribbean”. Two economic studies were also recently done which focused on the ground fish and sea bob fisheries (Drugan, 2019[31]; Isaac & Ferrari, 2016[32]; Willems, 2018[33]).

Protection status and vulnerability

There is **no specific protection status for marine ecosystem** in Guyana. Only the Shell beach is protected but now threaten by the development of the oil & gas sector. However, even if few studies have been made, marine ecosystem is considered as **highly productive and is of high importance** to Guyana’s development (Guyana’s national biodiversity strategy and action plan 2012-2020).

The marine ecosystem is increasingly becoming vulnerable due to the fast expansion of the offshore oil exploitation.

Criteria of importance for the ecosystem

Endemism	Very high
Richness	Very high
Connectivity	Very high
Climate change mitigation	Very high as the biggest carbon sink worldwide

[31] *Drugan, J. (2019). Environmental Sustainability Assessment: Guyana artisanal groundfish fisheries Executive summary. https://clmeplus.org/app/uploads/2020/06/Guyana-Environmental-Sustainability-Assessment_Artisanal-Groundfish-Fisheries.pdf*

[32] *Isaac, V. J., & Ferrari, S. F. (2016). Assessment and management of the North Brazil Shelf Large Marine Ecosystem. https://doi.org/10.1016/j.envdev.2016.11.004*

[33] *Willems, T. (2018). Impact of Guyana seabob trawl fishery on marine habitats and ecosystems: A preliminary assessment. https://fisheryprogress.org/sites/default/files/indicators-documents/Habitat%20and%20Ecosystem%20Report-Willems.pdf*

C. Impacting sectors in Guyana

Guyana is a **commodity-based economy** with a GDP per capita of nearly US$ 7,000 (World Bank, 2020) and a constant growth, that was 5,4% in 2019 and rose at 43,5% in 2020 after the launching **of oil&gas extraction.**

Historically and until 2019, **agriculture (rice, sugar) and extractives (gold, bauxite, diamonds, timber)** has been the twin engines of economic growth as the earnings from exports has had multiplier effect on the rest of the economy (investment, domestic expenditures). However, that while the rice industry continues to create growth, the **sugar industry is declining** (figure 19) and therefore Guyana recently engaged in a process of diversification of its agricultural sector (Perspectives on diversification prospects for the agri-food industry in Guyana, FAO, 2020).

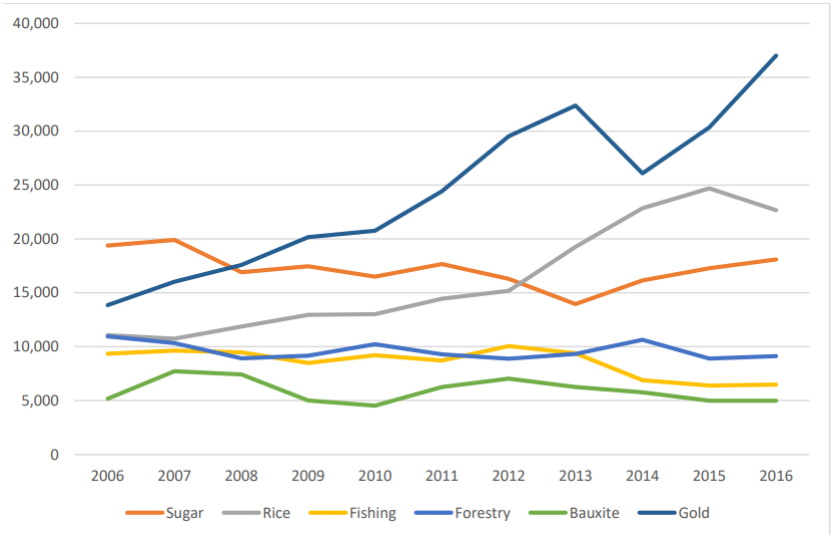


Figure 19 Contribution of GDP for key sectors. Source : WWF Guianas, Valuation of Guyana Fisheries Report, 2017

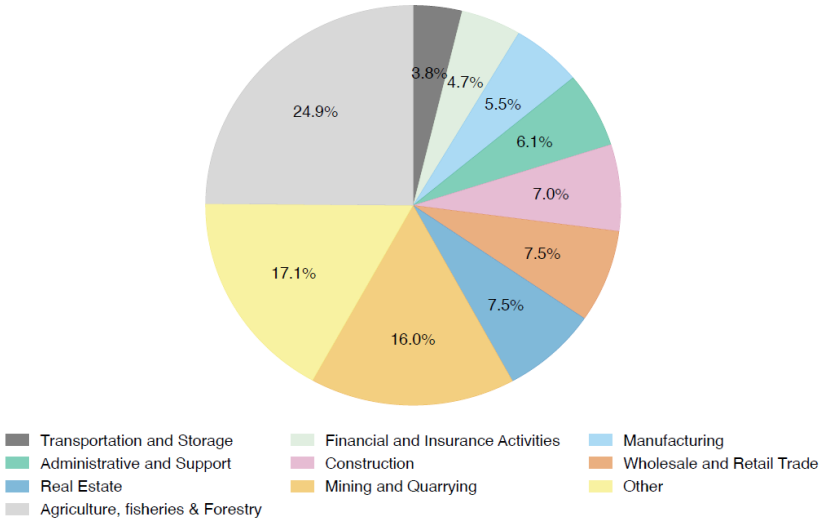


Figure 20 Sectoral contribution to GDP in 2019, based on Bank of Guyana data. Source : Inter-American Development Bank, 2020

The paradigm shift in 2019, because of the discovery of **high-grade hydrocarbons in 2015**, which created new perspectives for the country, Guyana being now known as the world's newest petrostate[34]. This new economic scenario forecast that oil exports are expected to reach almost 56% of exports, based on values of oil exports increasing from US$ 1.3 billion in 2020 to US$ 1.6 billion in 2021, despite both the coronavirus pandemic and an environment of low oil prices in the first half of 2020 (Interamerican development bank, Traversing a slippery slope, Guyana's Oil Opportunity, 2020)

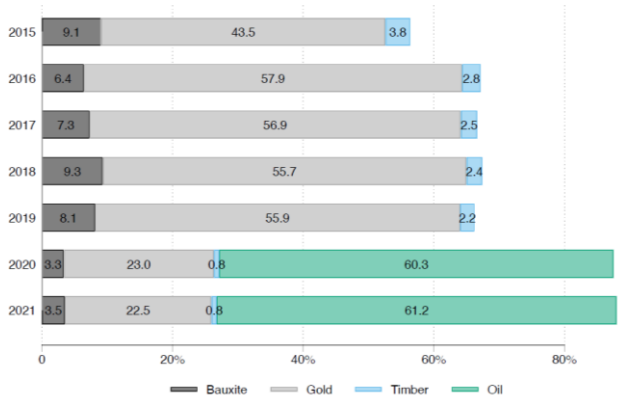


Figure 21 Extractive export as a share of total exports. Source : IMF Article IV 2019, Bank of Guyana, and IMF-WEO, 2020.

Though, since 2019 the following economic trends are rising:

- **Oil & gas** is an emerging source of economic wealth
- There are political intentions to **diversify the agricultural sector and the first industrial scale farm (Santa Fe) rose roughly 10 years ago.**
- In terms of energy, since 2012, Guyana developed a **low carbon development strategy** which includes many incentives to move toward the development of renewable energy.
- **Extractives (mining sector)** still constituted 16% of the GDP and more than 66% of the commodity export basket (Interamerican development bank, 2020).
- **Tourism** was rising up before the COVID pandemic, and Guyana received special prizes for its successful ecotourism activities.
- **Fisheries and aquaculture** are poorly studied but has a high development potential. It is considered as a structuring factor for the Guyanese society.

In that context of change, the 8 following sectors will be studied to understand better their place in the Guyanese economy, and their impact on biodiversity, both current and expected (future), direct and indirect:

- Mining sector
- Forestry sector
- Agricultural sector
- Fisheries and aquaculture
- Tourism sector
- Renewable energy sector
- Oil and Gas sector
- Banking sector

[34] *https://theglobalamericans.org/2021/04/saber-rattling-and-high-stakes-in-guyanas-geopolitical-neighborhood/*

C.1 Mining sector

Contribution to national economy

Mining has been a key driver of economic growth since more than 100 years, being the primary source of foreign exchange until 2019 (Thomas, 2009). On the 2012-2019 time period the sector contributed to **12% of the GDP,** this wealth being derived the following extractions:

- 8.9% from the gold industry
- 1.2% from the bauxite industry
- 1.5% from all other mineral mining activities

Even if mining activities started with bauxite industry, which operate for more than 100 years, the **gold production is nowadays the dominant one,** accounting for 66% of the mining output, 55% of the country's export value and foreign exchange (US$411 214 600), with **70% of the production being the result of artisanal small-scale mining** (ASM) (Liang & Moonsammy, 2021). As of 2021, gold industry turned second, representing 20.7% of the country's export value and foreign earnings (US$205,609,300) (Guyana Bureau of Statistics, 2021). Apart from gold, there is bauxite and diamonds (major activities) but also a variety of other mineral deposits including silica sand, kyanite, feldspar, copper, tungsten, iron, nickel (International Trade Administration, 2020).

In addition to its direct economic input, the mining industry has stimulated **side economic activities**, as people developed local enterprises to provide services such as lodging, catering, recreation, entertainment, transportation (ex: Bartica and Linden in district 3 and 4), which makes it an historical structing sector for development purposes in Guyana.

Area of impact

Six mining districts are demarcated in Guyana, and a major part of mining activity (especially gold) is carried out in the northern (center-west) part of the country, along the Cuyuni-Mazaruni region, in between the 2 respective rivers and on the frontier of the Potaro and Upper-Demerara-Berbice region, along the Essequibo River (figure 22). Those regions are in forests ecosystems, along rivers (for gold industry). As regard bauxite, glass sand, brick tile and ceramic clay extractions they are located on the white-sand plateau (northern-east side of the country).

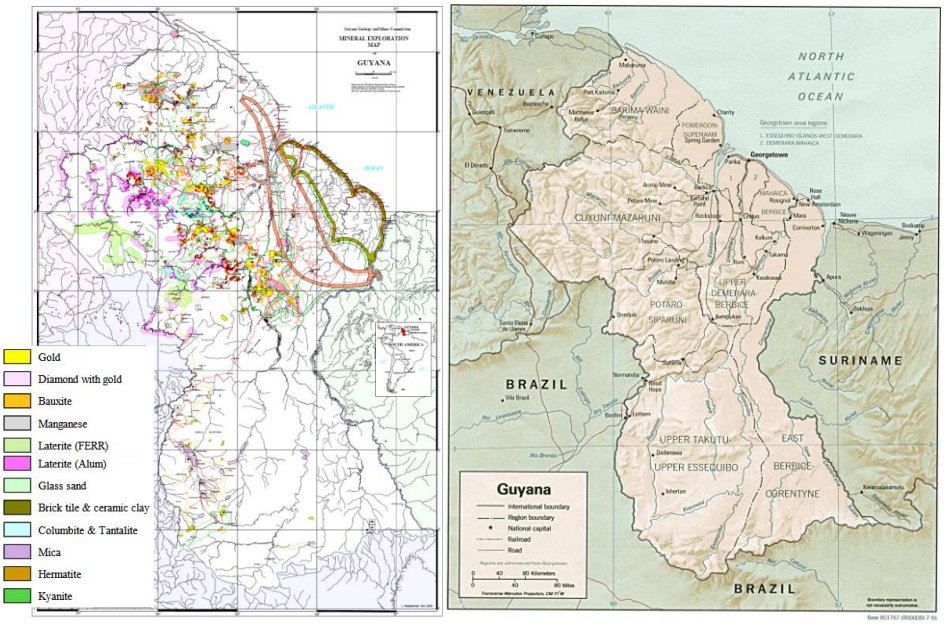


Figure 22 Mineral exploration map (left). Source : GGMC in Toward the Greening of the Gold Mining Sector of Guyana Transition, IDB, 2017; Guyana geography (right).

The three major ecosystems impacted by the mining sector are:

- Forests ecosystems
- Rivers and soils
- White-sand plateau

Indeed, mining is known as being the key driver of deforestation, **responsible for 87% of deforestation** in 2014 (GFC, 2015).

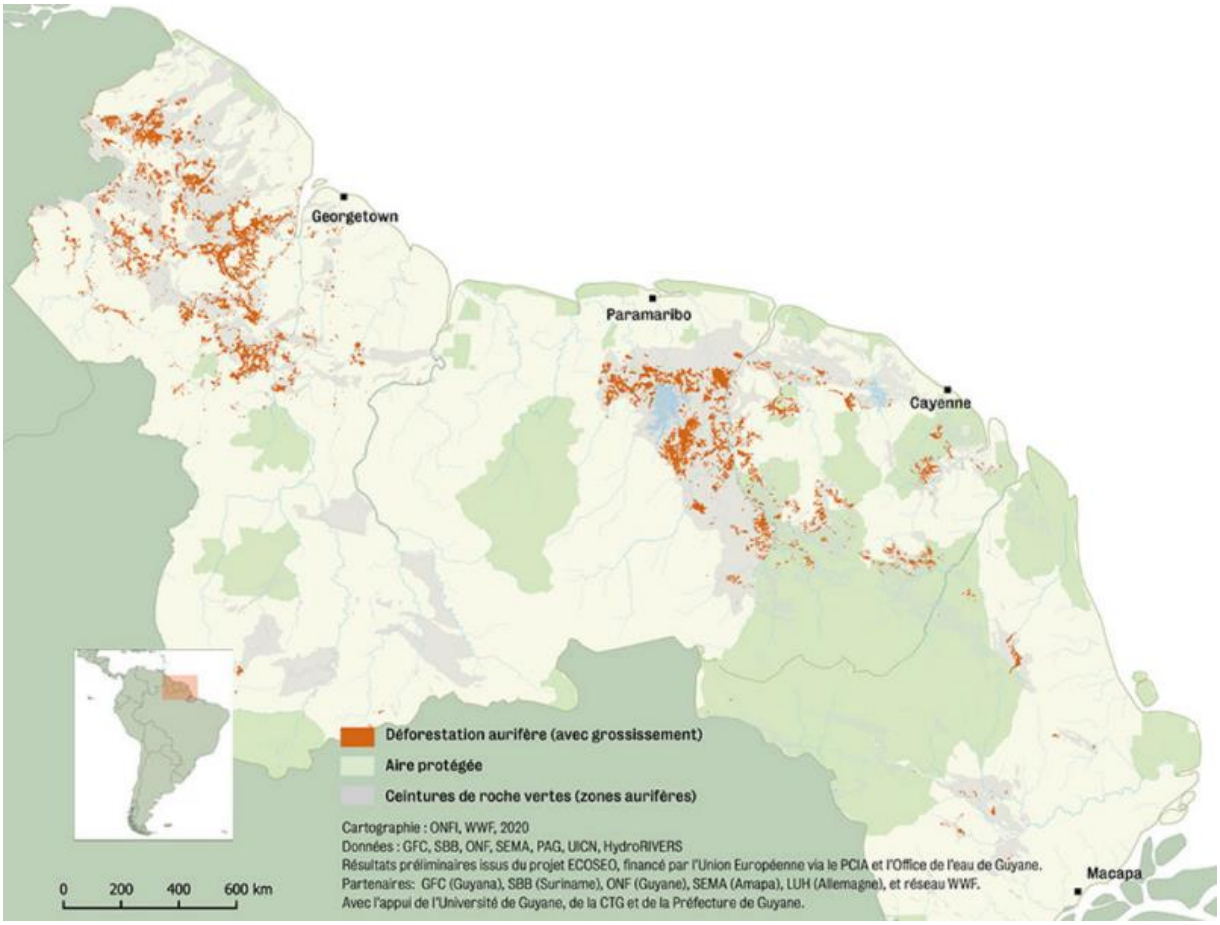


Figure 23 Deforestation due to gold mining. Source : ONFI, WWF, 2020

Description of impacts

Mining's impact on biodiversity is due to two main direct drivers (threats) which are land and soil clearing and chemical pollution.

- **Land and soil clearing,** corresponding to the **pre-extraction step,** are visible through deforestation map, and soil analysis.

Gold mining is the leading cause of deforestation in the country, mainly coming from the ASM sector, clearing small pockets of forested areas over a wider spatial range, but also coming from large bauxite and gold mining operations clearing large sections of a concentrated area like in Linden and Kwakwani area (Bholanath et Cort, 2015).

  - Direct drivers of forest loss are **forest clearing process** for the creation of mining pits, tailing ponds, for the building of mining facilities, and for the use of wood for fuel. Those processes create ecological disturbances which **affects the flow of ecosystem services associated**

with the habitat (hydrology regulation, erosion protection, sequestration services, fauna corridors).

- Additional drivers are due to **anthropogenic disturbances**. To access resources, humans' fragments forests habitats. The opening of forests (roads, infrastructures) for extractive purpose beak ecological corridors (fragmentation) which not only **increase carbon emissions**, but also cause habitat loss which generate biodiversity loss (Hansen et al., 2020[35], Rutt et al., 2020[36]). It also pave the way to **secondary activities such as hunting, bioprospecting, illegal mining, wood collection, settlements, which add additional pollution of waters, noise pollution, and other disturbances due to human intrusion.**
- In that context land-use pressure tend to rise and to building up, as the access for resource extraction attract an increasing number of people (Lennox et al., 2016), and **land-use pressure become an indirect driver of biodiversity loss**. Anthropogenic disturbance thus tends to double biodiversity loss from deforestation in tropical forests (Lennox et al., 2016[37]).

Soil habitats are also impacted causing varying degrees of **soil fragmentation**. Singh et al. (2013) estimate that a single dredge can remove up to 130 tons of soil a day. Using the GGMC estimates on the number of operational dredges, and estimated 520000T of topsoil is removed daily from mining activities. Even if this estimate needs to be taken with reserves, as more data is needed looking at **soil removal activity,** it reflects an intense **disruption of the substrate ecosystems** which results in **heavy sedimentation** in the river courses of the country, causing major ecological damages by increasing the turbidity of the water and reducing the water flow.

- **Chemical pollution,** corresponding to the **extraction step**, are visible through water (and its fauna) analysis and soil analysis.

  - Chemical pollution is the result of the discharge of heavy metals used to prospects minerals, and the most well-documented issue in Guyana concern the **mercury pollution from gold mining** (Hilson and Laing, 2017a; Lowe, 2006; Pasha, Wenner and Clark, 2017; Roopnarine, 2002; Singh et al., 2013).

Mercury is used in the a**malgamation process** of gold mining and as of 2015, Guyana imports between 7,5 to 22,5 tons of mercury annually (Legg et al., 2015) for the gold mining sector. The country also has an undocumented volume of mercury that is smuggled into the country mainly from the illegal mining operators in the country.

It has detrimental effect on the ecosystem which can be seen through analysis of the concentration of heavy metals in fish specimens. In 2001, the GGMC surveyed carnivorous freshwater fish and found that 57**% of the sample exceeded the World Health Organization (WHO) guidelines**. In 2000, Singh et al. reported the concentration of methyl mercury found in fish specimens across Guyana ranging between 0.24 – 1.81 ug/g with 39% of the specimens exceeding WHO guidelines.

The **mercury contamination** in the air, water and soils is persistent in the environment and accumulates over time. The accumulation eventually enters the entire biological system either through direct contamination or through **bioaccumulation in the food system** (from aquatic micro-organism to humans). The mercury pollution in Guyana has entered the food system (Singh et al., 2000) and contaminates people using the rivers to catch fish or as a source of potable water. Mercury levels contamination were assessed for indigenous people. Colchester et al. (2002) reported findings of 2 – 22 ug/g of mercury in hair samples of communities along the Barima River in Guyana. Singh et al. (2013) showed estimates from various indigenous communities across Guyana ranging up to 70.8 ug/g in hair specimens, some of which included nursing and pregnant women. The values reported were up to 5 times more than the WHO safety level.

---

35 Hansen et al., The fate of tropical forest fragments, 2020
36 https://www.sciencedirect.com/science/article/abs/pii/S0006320719315770
37 This study took a large data set of plants, birds and dung beetles (1,538, 460 and 156 species, respectively) sampled in 36 catchments in the Brazilian state of Pará. Catchments retaining more than 69–80% forest cover lost more conservation value from disturbance than from forest loss.

As from now, no assessment has been found as regard the contamination of megafauna in Guyana such as the Jaguar, Caimans or River Otters, but there is a high probability that wildlife is also impacted.

- As regards bauxite mining, it discharges aluminum, arsenic, cadmium, copper, chromium, lead, silicon and titanium at varying levels of concentration (chemical discharge also entering the ecology and food system). Not only do these pollutants enter the ambient environment during the bauxite operations, but residual pollutants persist even after the mined-out phase.

Williams et al. (2019) evaluated mined-out pits that were now lakes in Linden and found arsenic, cadmium, copper, chromium and lead in the soils of all the pits sampled though the ranges were within the WHO safety guidelines. The study also found aluminum, silicon, iron and titanium with average concentrations between 2 to 70%.

Bauxite mining operation also discharge **particulate matter** into the ambient air environment. The particulate matter discharge if left unchecked affects the surface areas of plants, threatens the insect populations and can afflict respiratory issues for the fauna around the areas as well. **From now, noncompliance with the mining regulation and accidents have been the major source of chemical pollution.** It is an indirect driver of biodiversity loss.

- As regard the **indirect drivers** of that section, it concerns the **mined-out management** as it created thousands of hectares of mined-out lands in the country.

Those areas are characterized by large deep ponds or lakes, steep and unstable landforms, extensive erosion, large, concentrated deforestation areas, and uncontrolled access leading to unlawful dumping and extraction of materials mainly for construction. To reverse deforestation in Guyana, a plan was formulated to **restore the mined-out areas**, and a decision was taken to introduce **non-native species**, Acacia (*Acacia mangium*), instead of natural processes such as ecological succession to occur eventually. Species has since spread into other areas where it was not planted and **encroaching on the native forest species** because of its fast growth rate, the characteristic that initially made it a good reforestation species (EPA, 2011b). The **introduction of invasive alien species** is therefore an indirect effect of mining industry.

Key drivers of biodiversity loss for the mining sector is the following

- Land and soil clearing (direct)
  - Forest loss
  - Anthropogenic disturbances due to the opening of forests
  - Topsoil removal, creating disruption of substrate ecosystems and sedimentation issues
- Chemical pollution (direct)
  - Pollution of waters and soil
  - Bioaccumulation of heavy metals (mercury), from river course, to wildlife, to human's food system, particulate matters
- Lack of mined-out plans leading to the introduction of alien invasive species (indirect)
- Noncompliance with mining regulations (indirect)
- Land-use pressure (indirect)

C.2 Forestry sector

Contribution to national economy

Logging has been conducted in Guyana for over **200 years** (Vieira 1980), but mechanization of logging appeared in the 1920s with the introduction of motorized sleigh-winches, then superseded by wheeled agricultural tractors, and in 1967, the use of chainsaws for felling and articulated rubber tiered skidders for extraction were introduced (Vieira 1980).

Nowadays 86.2% of Guyana's forest area is under the management and control of the Government of Guyana, of which **67% (12,2 million of hectares) are designated as State Forests** and placed under the management of the Guyana Forestry Commission (GFC). The remaining 12.9% are designated as State Land under the remit of the Lands and Surveys Commission[38] (ATIBT, 2020). Out of the 12.2 million hectares of State Forest, 38% (4,7 million of hectares) have been issued as timber concessions, of which 13% (1,7 million hectares) are large, long-term concessions, 17% (2 million of hectares) are small, short-term concessions and 8% (1 million hectares) are exploratory permit with no active timber harvesting operations yet (GFC, 2018)

The forestry sector has a **decreasing contribution to Guyana's GDP since 2010**, which was 1,81% in 2018, with an export value estimated at US$ 37.9 million, down 3.09% from the previous year (Guyana Forestry Commission, 2019).

GDP at Constant 2006 Basic Prices (G$M)				Forestry's Sub Sector Contribution to:	
Year	GDP	Agriculture Sector	Forestry Sub Sector	GDP	Agriculture Sector
2008	286,732	61,277	8,927	3.11%	14.57%
2009	296,086	62,838	9,161	3.09%	14.58%
2010	309,382	63,490	10,238	3.31%	16.13%
2011	325,457	65,268	9,289	2.85%	14.23%
2012	342,630	67,637	8,886	2.59%	13.14%
2013	359,822	69,230	9,330	2.59%	13.48%
2014	373,849	73,167	10,633	2.84%	14.53%
2015	385,270	74,863	9,501	2.47%	12.69%
2016	398,230	67,140	6,911	1.74%	10.29%
2017	406,698	67,408	7,543	1.85%	11.19%
2018	423,528	68,390	7,683	1.81%	11.23%

Table 2 Contribution of the forestry sector to national GDP. Source: Forestry Sector Information Report, 2018, GFC.

Area of impact

The impact of forestry is located in **the center of the country**, in lowland forest ecosystems (Figure 24) and has potential to grow on the white-sand plateau (Figure 25). However, even if it directly depends on forests, the forestry sector is the **3rd sectoral driver of deforestation** in the country, after mining and agriculture (Table 3).

[38] *The remainder are mainly privately owned, titled Amerindian Lands (13.8%) and protected areas (6.0%).*

Driver	Area (ha)	EF (t CO^2/ha)	Emissions (t CO^2/ha)
Deforestation			
Mining	5,248	1,045	5,484,630
Mining Infrastructure	573	1,045	598,836
Forestry	226	1,045	236,190
Infrastructure	52	1,045	54,345
Agriculture	246	1,104	271,623
Settlements	22	1,045	22,992
Fire	6,371	804	5,123,752
Deforestation Total	**12,738**		**11,792,369**
Degradation			
Timber Harvest			1,766,523
Illegal Logging			10,463
Mining Degradation		22	58,131
Degradation Total			**1,835,117**
TOTAL CO_2 EMISSIONS FOR GUYANA FOR 2019 FROM FOREST SECTOR			**13,627,486**

Table 3 MRVS results, 2019. Source: MRVS Report Assessment 2019, GFC, 2020.

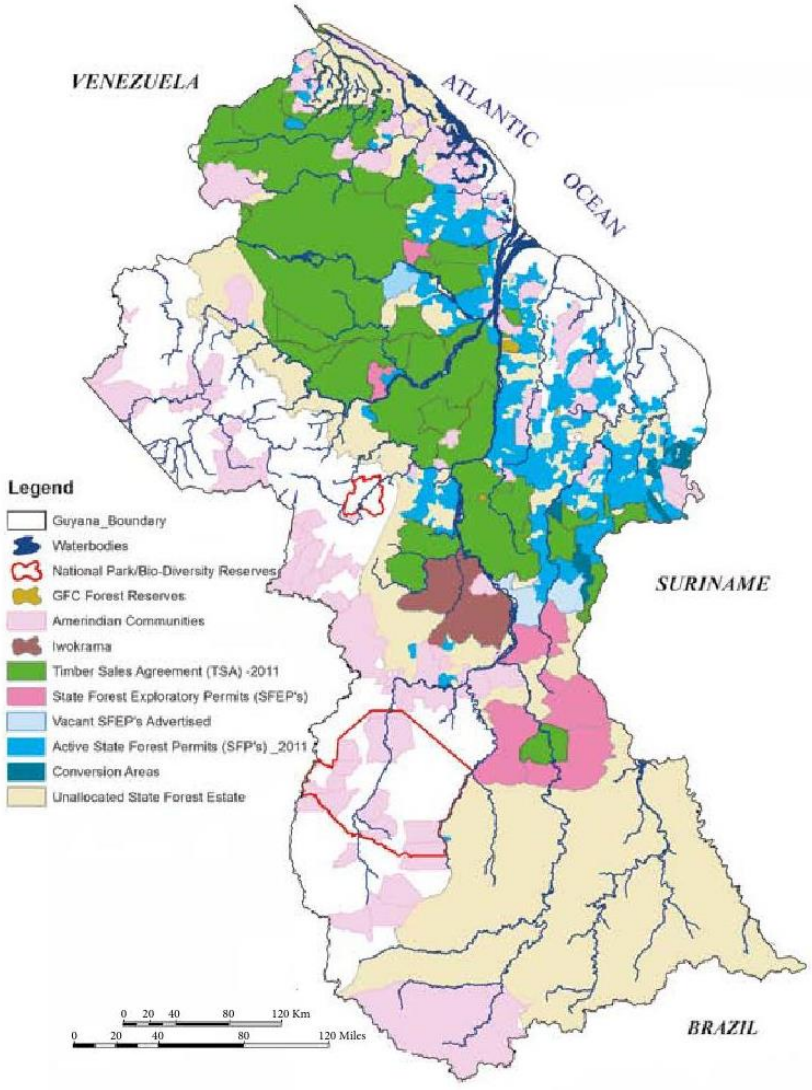


Figure 24 Forest Allocation Map Source: GFC, 2017

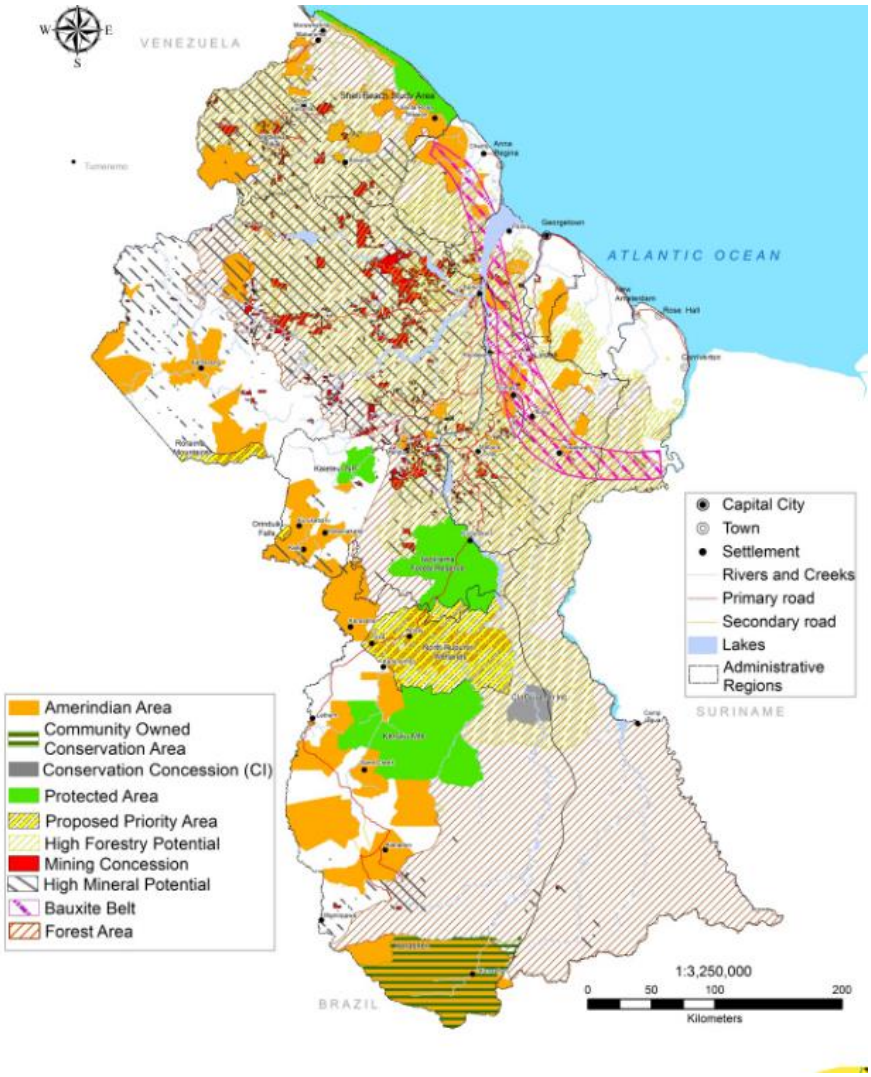


Figure 25 National land-use plan, 2017

Description of impact

Before the 2000's, conventional logging (CL) practices were especially detrimental to the most sought after high-value species such as *Chlorocardium rodiei* (Greenheart), *Peltogyne venosa* (Purpleheart), *Hymenea courbaril* (Locust) and *Diplotropis purpurea* (Tatabu). Trees were being harvested at a rate of 8.7 trees/ha which is an average of 27.8m3/ha and was considered to be highly unsustainable considering that 97% of the tree that was cut were *Chlorocardium rodiei*. This **unsustainable logging practices was all the more contributing to biodiversity loss as *Chlorocardium rodiei*** is endemic to Guyana.

In the mid-1990's, the 'reduced impact logging' (RIL) surfaced (Pinard et al. 1995) and some plannification started to merge in the years 2000 in Guyana (van der Hout, 2000). The **size of the felling gaps was reduced,** and more species were targeted (26) which reduced the pressure on *Chlorocardium Rodiei*, although the specie still account for over 50% of the number of trees felled (Van der Hout, 2000).

A study also proved that Iwokrama's logging regime, which is RIL awarded by **FSC certification in 2016**[39], is not disturbing the area's larger taxa, showing that responses (occupancy and detection rate) of

[39] *on its 371,000-hectare forest reserve https://news.mongabay.com/2016/12/fsc-certification-gives-boost-to-rainforest-community/*

large mammals and birds to RIL is even slightly positive (Roopsind et al., 2017[40]). In fact, in the Amazonian context, a **diverse mix of mammals is a good bio-indicator** as they play a pivotal role in the carbon cycle of tropical forests by feeding microbes that lock the carbon from food scraps in the soil (Sobral et al., 2017[41]). CL is therefore an indirect driver of biodiversity loss.

Nevertheless, even if the intensity has changed, the threats (drivers) stayed the same (both systems):

- **Cumulated canopy cover loss** is a direct driver, easily seen through remote sensing analysis

Forestry practices has a **direct impact** on the forest stand, extracting wood for commercial use, producing logs for exportation, which hold harmful ecological consequences in Guyana's context as only a limited number of marketable tree species are extracted **(indirect multiplier effect).**

For both RIL and CL, the average cumulative canopy loss is roughly 4.6% to 4.8% of the total logged area respectively, while the natural undisturbed cumulative canopy loss averaged just over 3% (Pereira et al., 2002). Apart from being a **direct habitat loss**, canopy gaps also **encourage the invasion of non-native species (indirect impact)** which can damage and/or change the native ecology and have negative effect on regeneration and seed dispersal (Baret et al., 2008; Devagiri et al., 2016; Hubbell et al., 1999; Jackson & Adam, 2020; Karsten et al., 2013; Pedersen & Howard, 2004; Qiang et al., 2019; Saiful & Latiff, 2019; Salvador-Van Eysenrode et al., 1998; Senécal et al., 2018; Hawes et al., 2020[42]). In areas where there is significant deforestation, the **albedo** would also increase and the canopy loss could cause **warmer and drier conditions** to occur in the understory when compared with undisturbed forests, which cause increased risks of fires (although there are not significant). Logging operation also has **negative effects on residual trees** (not targeted by the logging operation), with disruption of its growth form that may affect its survival if internal organs of the tree below the bask are exposed. Infections by various type of diseases (fungal, bacterial, viral) can then easily occur, create decay. Severe damages as split trunks, gouges, tops breaking off completely, etc. would most likely kill the tree (Figueira, 2008; Jalonen et al., 2014; Lee et al., 2002; Ng et al., 2009; Ratnam et al., 2014).

- **Genetic erosion** is a long stand impact

On the long stand, damage can be done at the genetic level. Since the desired phenotypes (straight boles, large diameter, little to no rot/decay, etc.) are removed for commercial use, that leaves the undesirable phenotypes (crooked boles, prone to decay/rot, etc.) which would make the stand undesirable for the main commercial purposes. On a genotypic level, genetic erosion will occur, and a significant amount of diverse gen types are removed from the stand which decreases the genetic diversity of the stand. A decrease in genetic diversity can make the stand **more susceptible to attacks from pests and diseases, natural hazards, the effects of climate change, etc.** (Leal et al., 2014; Sebbenn et al., 2008).

- **Ground clearance and disturbance** are direct driver seen through observations and soil analysis.

The skidding process creates a significant understory clearance. The use of heavy machinery **destructs the understory vegetation** and compact soils, which reduces the capacities of infiltration and consequently create excess of runoffs (Akbarimehr & Naghdi, 2012b; Arevalo et al., 2016; DeArmond et al., 2021; Donagh et al., 2010). **Soil erosion** is a big issue as the majority of eroded material from logging roads and skid trail temporarily end up in flood plains which can cause alteration to the habitat. In cases where the eroded material reaches waterways, the aquatic environment is altered (Akbarimehr & Naghdi, 2012a; Ampoorter et al., 2007; Arevalo et al., 2016; DeArmond et al., 2021; Donagh et al., 2010; Sidle et al., 2004). It also put significant pressure on species but also on **soil and microorganisms** which act to purify air and water whilst regulating climate and recycling nutrients (Popradit et al., 2015).

---

[40] *https://onlinelibrary.wiley.com/doi/abs/10.1111/btp.12446*
[41] *Sobral, M., Silvius, M.K., Overman, H., Oliviera, B.F.L., Raab, K.T., Fragoso, V.M.J. (2017) Mammal diversity influences the carbon cycle through trophic interactions in the Amazon. Nature Ecology & Evolution 1: 1670–1676. doi:10.1038/s41559-017-0334-0*
[42] *https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/1365-2745.13358*

As described above for the mining sector, the **opening of forests also paves the way to anthropogenic disturbances** and illegal logging, which add pressure on the ecosystems.

Keys drivers of biodiversity loss for the forestry sector are the following

- Loss of forest stand (direct)
  - Putting high pressure on species, soil and microorganisms
  - Creating disturbance in processes to purify air and water, regulating climate, recycling nutrients
  - Genetic erosion
- Cumulated canopy cover loss (direct)
  - Habitat loss resulting in disturbance of fauna and potential invasion of non-native species (indirect)
  - Rising of albedo effect, warmer and drier conditions
- Ground clearance and disturbance (direct)
  - Destruction of the understory vegetation, and increase of its vulnerability
  - Soil compaction and soil erosion
  - Alteration of aquatic environment
- Anthropogenic intrusions (direct)
- Conventional logging practices (indirect)

C.3 Agriculture (rice and sugar industry)

Contribution to national economy

Agriculture accounts for **19% of the national GDP** (2019), employ 30-33% of the country's labor force and is still dominated by small farmers (>60%). Rice and sugar have been the **two bedrock of Guyana's industrial agricultural sector since the colonial era.** Since the sugar market is decreasingly incentive at the global scale, the current political trend is to **diversify the agriculture sector and revitalize the sugar industry** (transformation) to not be fallen by Dutch Disease. More than 140 species of plants, from more than 100 plant families and 2 species of fungi, Oyster mushroom (*Pleurotus ostreatus*) and Common mushroom (*Agaricus bisporus*), are cultivated in the agricultural sector.

Rice is both consumed at national level and exported internationally. In 2017, according to the Guyana Rice Development Board, nearly 536,000 tons of rice were exported (compared with 500,000 tons in 2016). It is still considered as a **stable market** as global rice prices have a trend to rise (GBTI, 2019). On the contrary, the sugar industry is decreasing since global trading environment changed at Guyana's disadvantage. As a result, the government of Guyana has decided to cease operations on many of the country's sugar estates for a move diverse agricultural model that encompasses both the traditionally grown crops with non-traditionally grown crops (Guyana Ministry of Agriculture, 2013; Moonilall, et al. 2020).

Knowing that Guyana gathers all the conditions for this shifting to be successful (large arable land, favorable climatic conditions, traditional agricultural knowledge), this transition should work if political will sustain the following initiatives:

- **Fresh fruits and vegetables cultivation**, for the purpose of local consumption, with a high demand for citrus fruits, mangoes, papayas, coconuts, pineapples, roots and tubers, plantains, cucumbers and pumpkins.
- **Peanut production,** especially in the Rupununi region, that export peanut at the regional level (Caribbean market)[43]
- **Herbs and spices cultivation**, including hot peppers, shallots, cilantro

[43] *https://web.archive.org/web/20090903201058/http://www.usaid.gov/stories/guyana/cs_gu_peanuts.html*

- **Apiculture industry**, which started in 2018 with a great production of more than 11000 gallons of nectar annually (in 2019)
- **Organic cocoa, pineapple, heart of palm**
- **Few industries transforming raw agricultural products** (sugar and tropical fruits) into prepared foods (jams, jellies, molasses, fruit puree blends, coconut milk).

In 2020, the FAO published a report entitled « Perspectives on diversification prospects for the agrifood industry in Guyana » showing that Guyana is already almost prepare to produce more « sophisticated » products (manufactured products) as fish flour for animal feed, cocoa beans, palm oil and sunflower seeds. The agri-food system is also increasingly linked to **aquaculture** (see section on fisheries and aquaculture) and to the **tourism industry.**

However, aside from this small-holder farmer diversification trend, the opening of Santa Fe farm in 2010 has also shown that one possible future for the country could be to follow the **brazilian agricultural model**, based on intensive exploitation of commodities, highly impactful for biodiversity. In the next few years, the government might have to choose a developing model.

Area of impact

Agricultural lands are located mainly **on the coast** (figure 29) with 90% of the agriculture takes place on the low coastal plain. Polder culture are visible close to Georgetown, and agricultural front threat both the coastal ecosystem, **the white sand plateau and the surrounding forests**. Some forst patches can be found (figure 30) and in the heart of the country close to the Essequibo River.

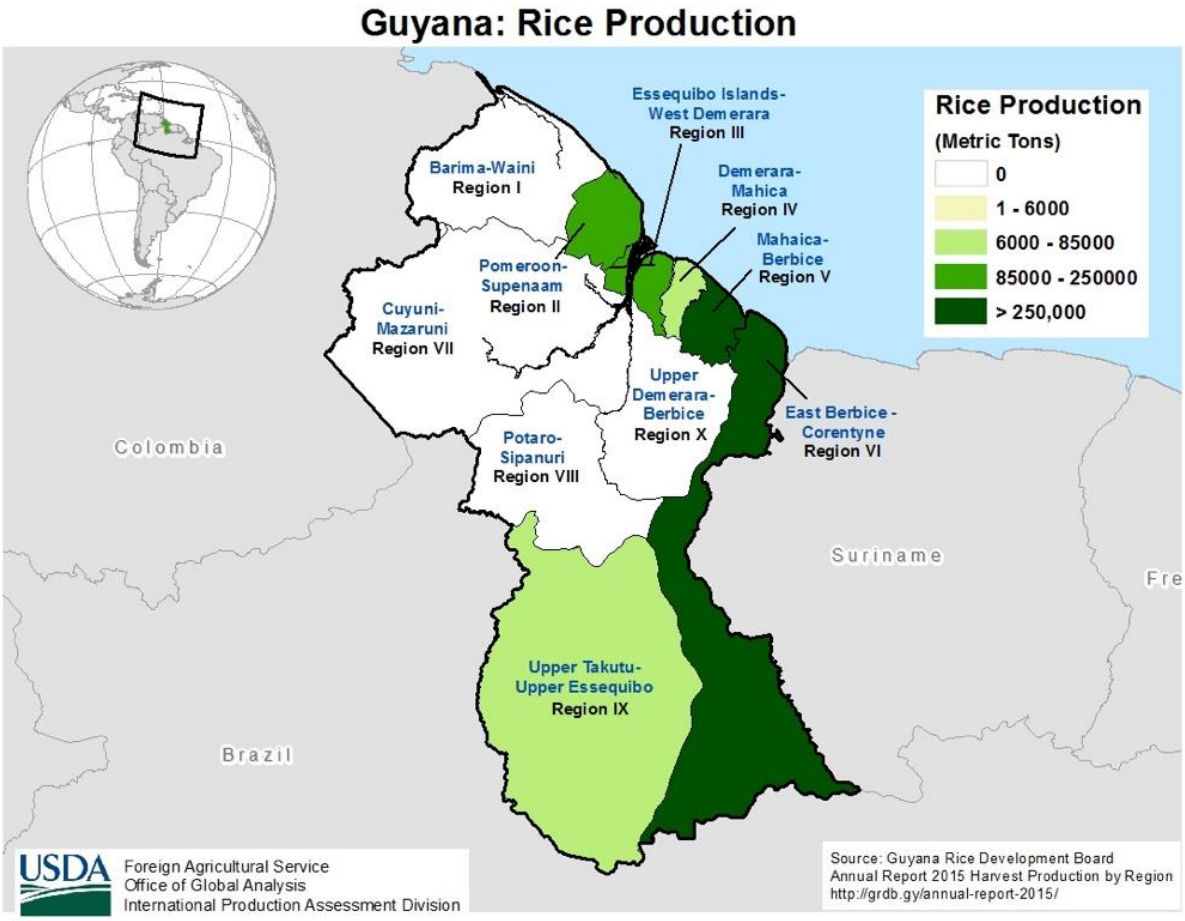


Figure 26 Rice production in Guyana. Source : Guyana Rice Development Board annual report 2015.

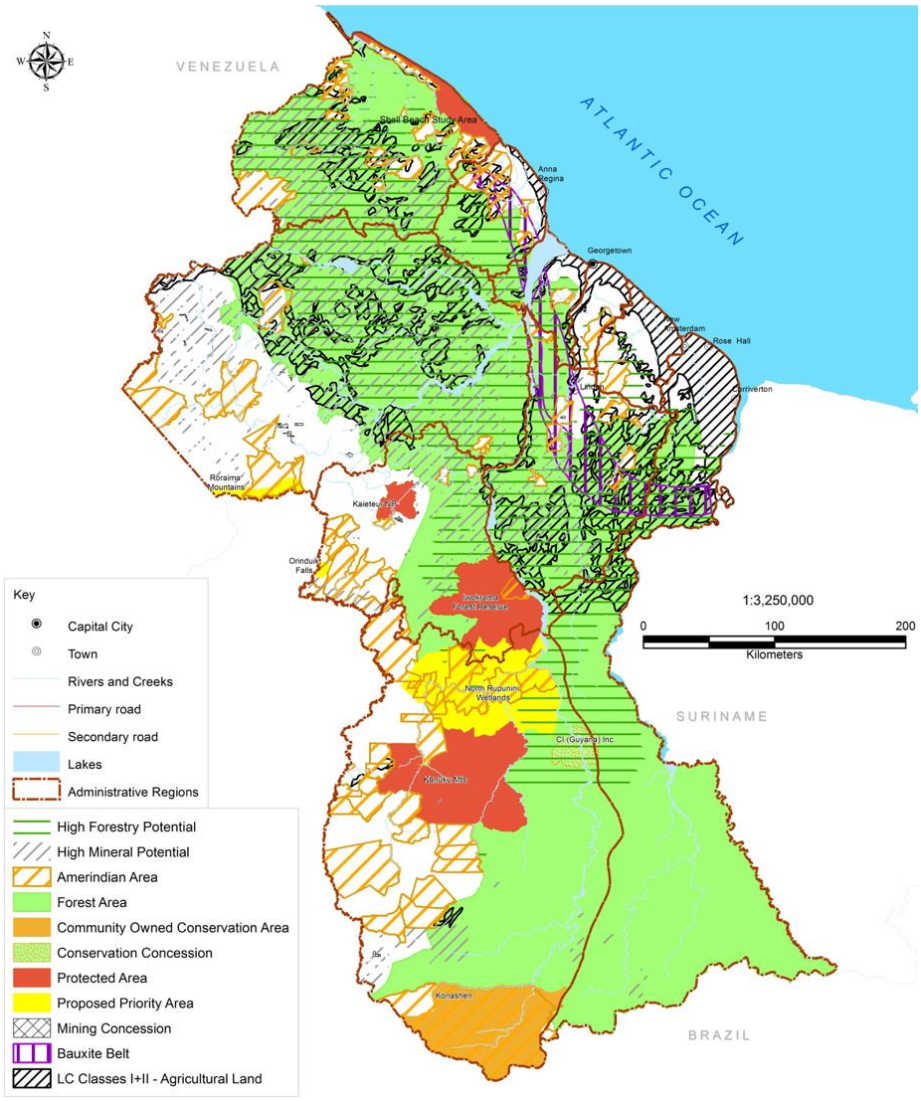


Figure 27 Assessment for Potential of Biodiversity Protection, Forestry, Mineral Resources and Agricultural Lands Source: (GLSC, 2013)

Description of impact

The agriculture sector has had a significant negative effect on Guyana's ecosystem and ecological processes, that have grown along with the sector over the years, and which is relatively well documented.

- **Deforestation and forest degradation**, in Guyana's context, is a direct driver of biodiversity loss
  - Agriculture is considered as the **2nd largest driver of deforestation of habitat loss**, due to agricultural practices, both on the coast with the creation of canal polders in the West Coast of Demerara, and in the countryside with land-clearing practices, due to the burning and the removing of forest cover, as visible in Linden-Soedyke areas.

Those disturbances, negatively impacts wildlife species with the most common being Capuchin Monkey and the Red Rum Agouti, threatening the **integrity of trophic chains (**domino effects), but also human living conditions, as the removal of the forest cover results in extreme **temperature variations** between day and night, which can cause **heat stress** on both the human and animal inhabitance. The removal of forest cover for agriculture also causes an increased release of carbon dioxide (potent greenhouse gas) into the atmosphere.

Mangroves are also particularly affected in Guyana's context. A correlation (R2 = 0.9821) has been made between agriculture and mangrove deforestation/degradation by Conservation International in 2018 (West Coast of Berbice), and it particularly concern the rice industry. In addition to clearing away the

mangrove, effluent produced by the industry is discharged in the mangrove stand which upset **various ecological processes** (Conservation International, 2018; NAREI et al., 2010), the most obvious one being the overloading of the metabolic pathways involved in the transformation and detoxification of pollutants. Mangrove removal eventually increase the risk of erosion, sedimentation, saline intrusion and heavy flooding during rainy season.

- Surface and ground water pollution are also direct drivers of biodiversity loss

In the crystalline plateau, unregulated, unmonitored, and unsustainable agricultural activities can put ground water resources on the coastal plain at risk of being contaminated. Since the gleysolic soil on the coastal plain is mostly impermeable, the water that infiltrates into the soil on the crystalline plateau then moves through the soil towards the coast via throughflow and gravity. When the water reaches the coast, it then **accumulates and forms aquifers** which are then tapped for various purposes.

A lot of the agricultural activity that is carried out in the crystalline plateau is **chemically intensive** because of the most nutrient-deficient nature of the albic aerosols which dominate the crystalline plateau. Use of urea can have negative effect on the soil as well as any chemical residues. Chemical residues can also get into the soil water and can be transported into the ground water which can cause a **decline in ground water quality**. Chemical residues from agricultural activities in Guyana also cause surface water contamination when transported to waterbodies via **excess runoff** (rice and sugar industry). In the rice industry, **agrochemical is highly used to reduce pest population**, in particular the paddy bug.

- **Soil degradation, destruction and contamination** are the final effects of those drivers

Apart from surface water pollution, soil biota is also negatively affected by the **overuse of agrochemicals**. Although these have not been extensive studies into the effects of excessive use of agrochemicals on soil microbiota, studies from a similar area show that agrochemicals significantly reduce the soil microbiota population in as little as 7 to 30 days after application. There is microbiota such as N-Fixing Microbes and Mycorrhizal Fungi which are both important components for nutrient conversion in the soil that are negatively affected and cause crop production to be significantly reduced. The reduction of the aforementioned **soil microbes** not only affect **crop production (soil fertility)**, but it can also negatively affect the normal growth and development of the natural vegetation which can **increase the risk of desertification** with implications for animals that depend on the vegetation for survival (Igbedioh, 1991; Kalia & Gosal, 2011; Mandal et al., 2020; Pimentel, 1989; Sidhu et al., 2019). **Tillage erosion** is also another phenomenon that is potentially common in Guyana but is not monitored and measured. However, other types of erosion, water and wind, are monitored under various projects. Studies from other parts of the tropics show that tillage erosion is far more common than water and winder erosion. There is a high probability that tillage erosion is one of the ecological effects of agriculture in Guyana. Another common types of erosion that can be observed throughout Guyana in various agricultural areas are water erosion (K. R. Olson, 2010; Wilken et al., 2020; Wysocka-Czubaszek & Czubaszek, 2014).

- **Contribution to climate change** is an indirect driver of biodiversity loss

For Guyana, agriculture contributes as much as 33% of the total greenhouse gas emissions. Agriculture has also been found to be a major source of methane and nitrous oxide which are both greenhouse gases with higher global warming potentials than carbon dioxide. **Rice cultivation alone accounts for 82% of Guyana's total methane emissions** and 94% of Guyana's total nitrous oxide emissions. Another major source of methane emission is livestock production predominantly due to enteric fermentation and the prescribed **burning of savannahs** which are done as part of land preparation for cultivation in some instances. The use of synthetic fertilizers are also a source of emissions and energy use is also a major source of emissions (GoG, 2012). Climate change heavily influences three variables, temperature, precipitation and the occurrence frequency of natural disasters. The occurrence frequency of natural disasters such as floods and drought are increased and these can result in the loss of habitats and the lives of various species (plants and animals) at a very fast rate which can cause dramatic population declines or extinction events (Behera et al., 2018; Mantyka-Pringle et al., 2015; Pires et al., 2018; Warren et al., 2013[44]).

[44] *Behera, M. D., Pasha, S. v, Tripathi, P., & Pandey, P. C. (2018). IPBES-IPCC CO-Sponsored Workshop Biodiversity and climate change. Current Science, 115(4), 608–609. https://doi.org/10.5281/zenodo.4782538.IPBES*

- **Erosion of genetic diversity** is an indirect long-term driver of biodiversity loss

Most of farmers have all abandoned the local cultivars, pursuing external high yielding cultivars and this reaction is because of shifts and increases in economic demands, sociopolitical factors such as receiving subsidies to do such, and technological change which points to this being an indirect driver. This practice has caused **75% of plant genetic diversity in agricultural sector of developing countries** to be eroded (Friis-Hansen, 1999; Hammer & Teklu, 2008). An example is the 2019 introduction of the **GRDB16 rice variety** which is higher yielding in high salinity conditions and increasing soil salinity is quickly becoming a problem **on the low coastal plain** of Guyana.

- **Introduction of invasive species** (in the case of the agricultural sector) is a direct driver of biodiversity loss

Invasive species have been introduced in Guyana as ornamental or decorative plants in the urban and built environment (EPA, 2011b)[45] but also in seeking to improve the productivity, decisions were taken to import and incorporate various exotic species, which became invasive, as the followings:

- *Echinochloa pyramidalis* (Antelope grass): one of the most invasive species on Guyana's coast growing in very thick mats and obstructing waterways which adds to the flood problem. As early as 1982 antelope grass was also recognized as one of **the main threats to the sugar industry and caused significant alterations in the aquatic environment while overwhelming and outcompeting other species** (Bushundial, 1991; Cumberbatch et al., 1996; Overholt & Franck, 2017; R de Araújo et al., 2021).
- Small Indian Mongoose (*Herpestes javanicus*): This species was originally introduced to Guyana in the 1900s to reduce the snake population in **the sugar industry**. The species is a predator that affects both livestock (poultry) and wildlife, and an opportunistic feeder that can feed on many other species, dead or alive. Those habits can significantly disturb the food web (Barun et al., 2010, 2011; Fineran, 2016; Scanes, 2018; Simberloff, 2001).
- Africanized Honeybees (*Apis mellifera scutellate*): Those species have not been introduced intentionally to Guyana, they migrated to Guyana from Brazil in the 1970's after escaping from a farm. After crossing into Guyana, they started to aggressively breed with the Italian Honeybees which were prevalent in Guyana at the time but has since bred out the Italian Honeybee strain from Guyana and remains the only strains used in Guyana's honey industry. The species became the main pollinator, responsible for over 70% of the sector's crop production. Studies have shown that they can outcompete and cause **the disappearance of native species, especially specialized competitors**. Removal or the disappearance of the Africanized Honey Bee can cause a complete ecological collapse in both the natural and built environments (Goulson, 2003; Jemmott, 2017; Roubik, 2002; Roubik & Villanueva-GutiÉrrez, 2009; Roubik & Wolda, 2001).

The list of key drivers of biodiversity loss for agriculture are the following

- Deforestation and forest degradation (direct driver)
- Surface and ground-water pollution (direct driver)
  - Decline in ground water quality
  - Impact on aquatic fauna

Mantyka-Pringle, C. S., Visconti, P., di Marco, M., Martin, T. G., Rondinini, C., & Rhodes, J. R. (2015). Climate change modifies risk of global biodiversity loss due to land-cover change. Biological Conservation, 187, 103–111. https://doi.org/10.1016/J.BIOCON.2015.04.016
Pires, A. P. F., Srivastava, D. S., Marino, N. A. C., MacDonald, A. A. M., Figueiredo-Barros, M. P., & Farjalla, V. F. (2018). Interactive effects of climate change and biodiversity loss on ecosystem functioning. Ecology, 99(5), 1203–1213. https://doi.org/10.1002/ECY.2202
Warren, R., VanDerWal, J., Price, J., Welbergen, J. A., Atkinson, I., Ramirez-Villegas, J., Osborn, T. J., Jarvis, A., Shoo, L. P., Williams, S. E., & Lowe, J. (2013). Quantifying the benefit of early climate change mitigation in avoiding biodiversity loss. Nature Climate Change 2013 3:7, 3(7), 678–682. https://doi.org/10.1038/nclimate1887

[45] *Antidesma ghaesembilla (Black Currant), Caesalpinia pulcherrima (Barbados pride), Calotropis procera (Apple of Sodom/Madar), Casuarina equisetifolia (Australian-Pine), Hedychium gardnerianum (Kahili Ginger), Melaleuca quinquenervia (Niaouli or Broad-Leaved Paper Bark), Terminalia catappa (Alconorque/Wild Almond), Thunbergia grandiflora (Bengal Clock Vine), Tithonia diversifolia (Japanese Sunflower).*

- Soil degradation, destruction and contamination (direct driver, results of the submentionned drivers)
  - Use of agrochemicals (especially in the rice industry)
  - Reduction of soil microbes à reduction of soil fertility and increase of the risk of desertification
  - Tillage erosion, and other sources of erosion
- Contribution to climate change (indirect driver)
  - Methane emissions (rice industry)
  - Burning of savannas
  - Use of synthetic fertilizers
- Erosion of genetic diversity (indirect long-term driver)
- Introduction of invasive species (especially in the sugar industry) (direct driver)

C.4 Oil and Gas

Contribution to national economy

In Guyana, the oil and gas industry started to be an issue in 2015, when a consortium of three major oil companies (Exxon Mobil, Hess holds and China's Cnooc Ltd) made an **offshore oil discovery in the Stabroek block, located about 120 miles (200km) off the country's coast** and growth scenarios and projections have been completely turned upside down.

In 2017, Exxon Mobil announced that the company expected to produce **$2 to 2,5 billion oil-equivalent barrels from Guyanese waters**, which could add up to more than $100 billion[46] . The exploitation started in 2019, in 2020, the production was confirmed as being more than $8 billion oil-equivalent barrels[47] with 15 discoveries. At a 2025 horizon the company now plan to extract 800,000 barrels per day[48], fully dedicated to exportation. Gas deposits have also been founded (the country currently imports its gas).

In that context, oil production is expected to be the **main driver of economic growth in the following years.** In October 2019, the IMF estimated that GDP would grow by 85.6 percent in 2020, which was reviewed to 52,8% in April 2020 in a post-pandemic context, and one-third of the World Bank's budget for Guyana is allocated to develop the institutions to manage this oil extractive activity[49]. In January 2021, a **Venezuelian decree (N°4.415**), also claimed exclusive Venezuelan sovereignty over the waters and seabed off of Guyana's coast, west of the Essequibo River, as part of a strategic area for its national development. This space in Guyana's Atlantic "facade," include those petroleum resources, and now forms part of the unilaterally pronounced Venezuela's "Territory for the Development of the Atlantic Façade". This geopolitical conflict reflects the underground geopolitical conflict between USA and China, as in April 2021, Taiwan opened a commercial office in Guyana, supported by the USA, and China reinforced its alliance with Venezuela[50]. **This rise of international tensions in Guyana are the sign of the great influence and power the oil sector has and will have in the future**. The case is now under the ruling of the ICJ[51]

[46] *https://news.mongabay.com/2017/11/guyana-seeks-offshore-oil-wealth-in-a-green-economy/ https://www.forbes.com/sites/clairepoole/2017/01/12/big-oil-discovery-could-boost-growth-at-exxon-mobil-hess/?sh=58f32b5e136b*
[47] *https://www.kaieteurnewsonline.com/2020/01/28/stabroek-block-estimates-moved-to-8-billion-oil-equivalent-barrels/*
[48] *https://www.argusmedia.com/en/news/2214501-exxonmobil-ups-guyana-2025-oil-target-to-800000-bd; https://www.theguardian.com/environment/2021/aug/17/exxon-oil-drilling-guyana-disaster-risk*
[49] *https://projects.worldbank.org/en/projects-operations/project-detail/P166730?lang=en*
[50] *https://apnews.com/article/global-trade-south-america-china-guyana-asia-pacific-05b5d78db7a08fc5baba983b39d5463f ; https://thediplomat.com/2021/02/the-strange-saga-of-taiwans-short-lived-office-in-guyana/*
[51] *https://conversationtree.gy/venezuela-escalates-threat-to-guyana/*

Area of impact

The area of impact in located in the **Atlantic Ocean**, about 120 miles (200km) off the country's coast, and on the coast, where infrastructures will be developed to ensure storage and export activities. The coast will be the area where indirect impact of the oil extraction will be seen.

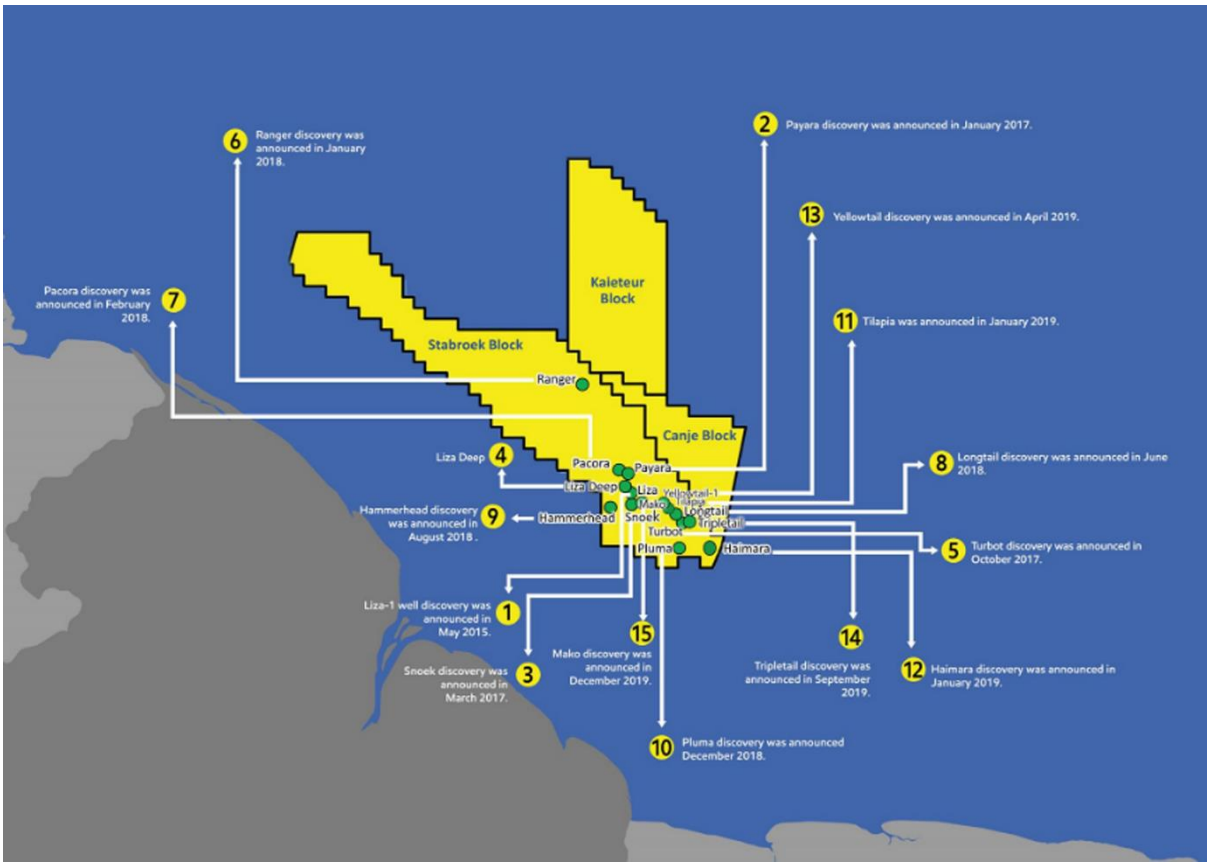


Figure 28 15 of ExxonMobil's discoveries. Source : Kaieteur News Online, 2020.

Description of impact

As the activity is quite new, no study has informed the impact yet, even the full development program for offshore oil and gas production is yet to be known. Though in may 2021, the World Wildlife Fund (WWF) called for a **full environmental and social assessment of Guyana's oil and gas development**[52]. The following impact are then the one we can except, based on what happened in similar countries, with similar activities, both directly in the ocean, indirectly on the coast and possibly in the case of a disaster.

- In the ocean, the increase of marine traffic is a direct driver of biodiversity loss in the **marine environment**.

As the marine traffic will increase, collisions with marine life will rise. Consequences on fauna and flora will be both **physical (engulfment, smothering of habitats, noise pollution) and toxic (contamination of organisms by chemical processes and chemical leaks, decreasing of water quality).** Considering that among the 20 critically endangered species, 14 belongs to marine fauna. The endangered sea turtles (Green turtle - *Chelonia mydas*, Leatherback turtle - *Dermochelys coriacea*, Hawksbill turtle - *Eretmochelys imbricata*, Olive Ridley turtle - *Lepidochelys olivacea* and Loggerhead turtle - *Caretta*

[52] *https://oilnow.gy/featured/wwf-calls-for-full-environmental-assessment-of-oil-and-gas-operations-in-guyana-applauds-tougher-measures-for-flaring/*

caretta) that breed and live along Guyana's north-west coastal region might be highly impacted[53]. The marine seismic activity also creates particularly damaging effects by creating **empty corridors**. As a secondary effect, a decline in fish population will have high consequence on the **entire trophic chain, highly connected in the marine ecosystem** (cf: marine ecosystem section) and on other sector as the fisheries industry and the tourism industry (ie: Northwest area, Shell Beach, where the sea turtles breed and live).

- On the coast, the main direct impact will be the **development of infrastructure for the oil industry** that will lead to deforestation and disturbance of mangrove habitat.

Mangrove habitat might be destroyed for the purpose of transportation, storage and export activities. Its **functions of filter, carbon sink, protective barrier against natural hazards, nursery, structural functions** will then be altered. Also, mangrove removal will eventually increase the **risk of erosion, sedimentation, saline intrusion and heavy flooding during rainy season**. The urban pressure will also increase, due to the increase of human settlement (economic activity being the corollary of human settlement), industrial wastes, pollution, soil asphyxiation etc.

- For the future, the **disaster risk is also very high**, especially in the case of an oil spill, this is a supposed future driver of erosion

In fact, Guyana's response capacity is very low (weak institutions, patronage, indebted country) and the contract signed with Exxon Mobil stipulates that **the country is responsible for the clean-up in the likely scenario that there is an oil spill**[54]. Even though entire **marine species can disappear** over a large area, as well as **birds that might be engulfed in crude oil**, dying from asphyxiation, the toxicity of ocean and coast might rise up very fast. In fact, Exxon's plan for a potential oil spill response relies on methods heavily criticized, especially a regard the use of Corexit 9500, a chemical dispersant used for the Exxon Valdez (1989) and BP oil Spill (2010) which increases the **toxicity of oil by 52 times**[55]. This dispersant is banned in United Kingdom and Denmark. Another announced intention is the one-off **burning oil on the ocean surface even though it is drilling in the Amazon-Orinoco Influence Zone,** an area rich in marine biodiversity, with rare and threatened species on which local Indigenous and other fishers depend (The Guardian, august 2021[56]). Finally, the permit for Liza phase 1 does not require to use a blowout preventer for ultra-deep drilling, which creates an additional risk.

- An indirect driver is linked to **political choices**. Despite the orientation of the Low Carbon Development Strategy that started in 2012, the government decided to seize the oil&gas opportunity to gain economic growth, which is a **highly carbonated economic activity.**

Oil extraction **will highly contribute to global warming**, as this oil will eventually be burned (indirect impact). It is estimated that125m metric tons of carbon dioxide will be released per year from 2025 to 2040, from drilling the oil to burning it (Environmental Law Alliance Worldwide, 2020). Exxon also flares, or burns, its excess gas. In the first 15 months of production alone, that flaring contributed nearly 770,000 metric tons of greenhouse gas emissions – the equivalent of driving 167,000 cars for one year (The Guardian, august 2021[57]).

Key drivers of biodiversity loss for the oil & gas sector are the following

- Increase of the marine traffic (direct)
  - Disturbance of marine fauna
  - Engulfment, smothering of habitats, noise pollution
  - Contamination of organisms by chemical processes and leaks

[53] *https://news.mongabay.com/2017/11/guyana-seeks-offshore-oil-wealth-in-a-green-economy/*
[54] *https://news.mongabay.com/2020/11/guyanas-future-and-challenges-in-oil-qa-with-filmmaker-shane-thomas-mcmillan/*
[55] *https://www.sciencedaily.com/releases/2012/11/121130110518.htm*
[56] *https://www.theguardian.com/environment/2021/aug/17/exxon-oil-drilling-guyana-disaster-risk*
[57] *https://www.theguardian.com/environment/2021/aug/17/exxon-oil-drilling-guyana-disaster-risk*

  - Decreasing of water quality
- Development of infrastructure for the oil industry
  - Mangrove deforestation
  - Alteration of its structural functions
- Rise of human settlements (urbanization) (indirect)
  - Waste, pollution, construction, soil asphyxiation
- Risk of ecological disaster (future, predictable)
  - Loss of fauna (marine, birds)
  - High toxicity
- Political choices (indirect)
  - Contribution to global warming

C.5 Fisheries and aquaculture

Contribution to national economy

The fishery sector is under-studied, under-researched, in Guyana. The latest baseline evaluation for the sector have been done in 2017 as part of the Blue Green initiative (Valuation of Guyana's Marine Fisheries, WWF), which is the main source of the following information. Another study on seasbob fishing impact (Vottunarstofan Tún ehf., 2019) confirmed that research are quite limited, apart from the recent work by Willems on benthic species assemblages (Willems 2018), habitat mapping by CEFAS and early work by Lowe-McConnel.

Fisheries contributed to **roughly 2% of the GDP** (Guyana Bureau of Statistics 2017), declining from a higher 4% ten years ago (in 2006), mainly due to the overall growth in other sectors of the economy. Though it contributed little to the economy, the sector is considered as economically and socially important in Guyana. Over 20 000 people are officially estimated to be involved through the commercial capture or other fisheries dependent activities (CRFM, 2014), to which the informal and artisanal part, underestimated if not misestimated, should also be added. In fact, fisheries are key to food safety as it both provide an affordable, dependable, and stable source of protein and a social safety net, as the activity is organized through family networks, all working in the value chain of sea products. As regard commercial fisheries, **shrimp and prawns are the fifth largest source of foreign exchange**, as an export product representing, 3,4% of total exports (Guyana Bureau of Statistics 2016). As part of this study only the commercial industry will be studied[58].

In the last two decades exports of species such as **grey snapper and shark has increased, with sub-sectors focusing on sea bob, finfish and shrimp,** exported in the United Stated of America, Japan, CARICOM countries and the European Union (MacDonald et al 2015).

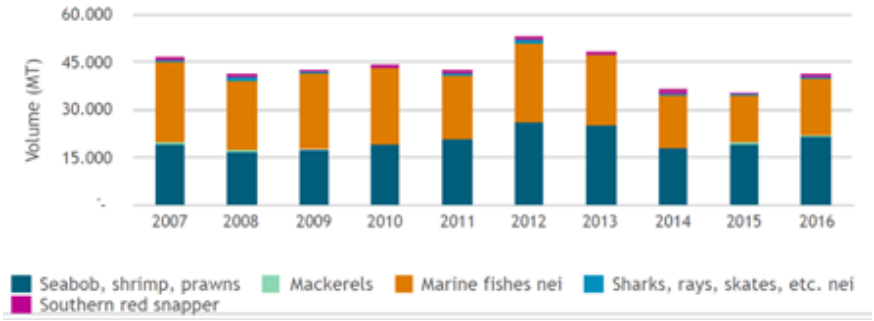


Figure 29 Guyana marine capture production from 2007 to 2016 (Source : GoG, 2019 ; FAO, 2018)

[58] *It has been chosen, in accordance with WWF-Guianas, that the informal activities won't be studied as part of BIODEV2030, as for the second phase, sector should create voluntary commitment, which can only be made if the sector is structured enough to do so.*

In recent years, aquaculture was also promoted to encourage the **diversification from traditional agriculture (sugar, rice).** The activity started in 1940's with the introduction of the Mozambique tilapia (*Oreochromis mossambicus*), with attempts to **produce fish in irrigated rice field or flooded sugar cane fields**. However, at that time, the government placed more emphasis on the development of marine capture fisheries, which decreased the dynamic promoting aquaculture. The interest was then renewed in the 1970's with the introduction of the Nile tilapia (*Oreochromis niloticus*) and the giant river prawn (*Macrobrachium rosenbergii*), but never took off (FAO, 2018). In 1994, a draft Action Plan for Aquaculture Development, was prepared with the support of the Canadian International Development Agency (CIDA) to establish freshwater **fish farming station**, and since 1997, the Government has embarked on an aquaculture expansion drive. In that year, the Jamaican red tilapia (hybrid) was introduced with a second introduction in 2001, as part of the Phase 1 of the M**on Repos Freshwater Aquaculture Demonstration Farm and Training Centre**, an aquaculture hatchery, inspired from traditional knowledge[59], to promote freshwater aquaculture, financed by the Government, the Food and Agricultural Organisation (FAO) and the Canadian International Development Agency (CIDA). In 2019, FAO financed a new project focusing on the improvement of the **Atlantic sea bob value chain**, as part of the FISH4ACP[60] program. Today, **Guyana is the world's largest producer of Atlantic sea bob**, and this aims to enhance the productivity and competitiveness of the Atlantic sea bob fishery in Guyana, where local demand is expected to rise as a consequence of emerging oil and gas production. The project also aims to increase the production of small-scale fishers in the sector and strengthen the role of women and youth, while seeking to improve safety and workers' rights.

On the low Atlantic coastal areas, pond culture of tilapia and giant river prawn being the main farming system. Experiments are also made to link aquaculture with agriculture (**rice-fish farming in Berbice,** experimental pond rearing of the giant river prawn, *Macrobrachium rosenbergii*, in several regions, freshwater culture using grain bran)[61]. Brackishwater farming is also present with traditionnal practises involving the opening of the sea defenses to take advantage of tidal inflows. During high tides, juveniles, larvae, eggs, etc. are trapped in coastal polders and in some cases, enclosures are constructed near the foreshore where they are allowed to mature to marketable size. These impounded waters contain many species with the targeted one: salmon shrimp (*Mesopaeneus tropicalis*), common snook (*Centropomus undecimalis*), tarpon (*Megalops atlanticus*) and mullet (*Mugil spp.*) (FAO,2005).

In year **2019, the aquaculture production reached 243 tons**, which is low, but despite this, the need for **diversification and complementarity with marine fishery sector**, and the expected high demand due to the development of the oil industry on the coast, could attract investment some investment to develop the sector in the coming years.

Area of impact

The area of impact is **the Atlantic coastal area** (with an Exclusive Economic Zone, in an area equivalent to 64 percent of the country's landmass), the extensive terrestrial network of rivers (ITA, 2021) and some cropped lands as experiments for aquaculture.

Description of impact

The impact of fisheries is poorly documented. In 2019, the draft of the Marine Stewardship Council Fisheries Assessment has been made public (Vottunarstofan Tún ehf., 2019) and based on the studying of the sea bob fisheries, bring element to tackle the impact of fisheries in Guyana. Fisheries count as a large part of the subsistence for the local market, and as a little impact compared to other sectors. Nevertheless, selective fishing and the creation of coastal dikes for aquaculture has significant effect.

---

[59] *The first attempts at aquaculture in Guyana can be traced back to the early Indian inhabitants of the eastern Corentyne Coast near the Berbice River estuary. They practised legal or illegal opening of the sea to take advantage of high tides. Juveniles, larvae, eggs, etc. are then trapped in coastal polders and in some cases in specially constructed pens near the foreshore where conditions ensure good growth and maturity to reach commercial size (FAO, 2005)*

[60] *http://www.fao.org/3/cb1543en/cb1543en.pdf*

[61] *FAO Fisheries & Aquaculture - National Aquaculture Sector Overview - Guyana*

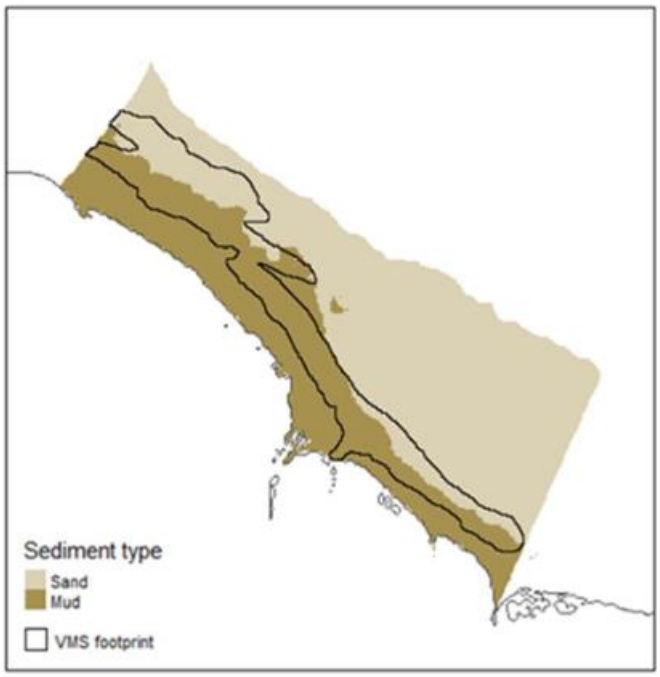


Figure 30 Fishing footprint in relation to sediment type. CEFAS, 2018.

- **Selective fisheries and bycatchings** are the two first direct driver of biodiversity loss

The over exploitation of stocks is the first threat to the marine ecosystems, which lead to **the decline of species quality and amount** (WWF, 2017). Guyana focuses on flagship species (seabob, tilapia), which put **high pressure** on it, and reduce the general diversity. A study done by Willems et al. in 2015 indicated that communities of benthic invertebrates (epifauna) appeared to be dominated by seabob shrimp, with little other species present on seabob trawling grounds.

In terms of species, bycatchings are common (Vottunarstofan Tún ehf., 2019), especially for rays, baby sharks and turtles (Medley, 2018), sea turtles being particularly vulnerable for catch and consequently **drowning in fishing nets including shrimp trawls** (Crowder et al. 1995). Smaller species are also catched unintentionally.

- **The creation of coastal dikes** (hard coastal defense) to protect aquaculture estates is also a direct driver of biodiversity loss

Apart from **land artificialization**, those coastal dikes are **less effective in dissipating wave energy** than mud banks and disturb processes involved in the consolidation and subsequent mangrove colonization of mud banks[62]). The mud supports a rich invertebrate fauna that nourishes a variety of demersal species (FAO, 2005), which is in the scope of the fishing activity, and are impacted by the creation of those coastal dikes.

However, the impact on marine habitats (for sea bob fisheries) seems to be **limited and localized** in Guyana, due to the naturally dynamic environment (muddy seabed in the areas trawled for sea bob shrimp). The trawl that is used is relatively lightweight and the fishery is limited to water depths of between 18-30m (Willems, 2016). Still, for the sake of fisheries, **mangrove deforestation is a threat to be foreseen**. It hasn't been formally assessed yet but it is an observed trend in many parts of the world (Al Robertson, 1987; Campbell, 2021; K Ikejima, 2003; Natalia Siahaan & Wasiq, 2020; Shinnaka et al., 2007). As mangrove forests serve as a reproductive nursery feeding and protective cover for various fish species, mangrove's deforestation will include the need for an increased traveling distance to secure

[62] *available here: https://www.sciencedirect.com/science/article/abs/pii/S092585741200256X*

adequate catch (WWF, 2017), which will be a growing intrusion into the marine ocean and a threat for the equilibrum of the seabed.

- Finally, the **introduction of invasive species**, Gold tilapia (*Oreochromis aureus*), Mozambique Tilapia (*Oreochromis mossambicus*), Nile Tilapia (*Oreochromis niloticus*), is a major issue.

Today, tilapia is one of the most common species that can be found in Guyana's waterways since they **outcompete most of the native species** because of their hardiness and ability to survive in both fresh and brackish water if needed. They can also survive and successfully reproduce in high disturbed habitats that native species cannot.

Key drivers of biodiversity loss for the fisheries and aquaculture sector are the following

- Selective fisheries and bycatches (direct)
  - Loss or decline of species (amount and quality)
- Creation of coastal dikes (direct)
  - Disturbance of the mud ecosystem that can even extent to marine environment (direct)
- Mangrove deforestation (predicted)
- Introduction of invasive species (indirect)

C.6 Tourism

Contribution to national economy

In 2019, tourism contributed to **10,4% to the GDP** and represented 4,8% of total employment, 5,5% of the GDP and 3,9% of total employment in 2020, this drop being mainly due to the Covid-19 pandemic (World Travel & Tourism Council, 2021). Turner (2015) forecasted that the tourism industry will potentially support 18 000 jobs (7.3% of total employment) by 2025.

In fact, several type of tourism can be seen in Guyana. **Business and leisure tourism is increasingly growing since 2019 due to the country's oil boom**. New hoteliers, restaurants, and transport services businesses has opened, all to benefit from the anticipated surge in foreign visitors coming into the country. Concerning ecotourism, Guyana from have a **high potential to develop nature-based tourist niche** (Wenner et al., 2015), with is a comparative advantage at the regional scale[63]. The country has been rewarded from 2011 to 2013 by the Caribbean Tourism Organization (CTO) with the travel most sustainable tourism awards and has been recognized as the number 1 destination for ecotourism in 2019 by the International Travel Agent Magazine.

This sector is confirmed to be a pillar of the national strategy, as highlighted in the draft of the Guyana Tourism Strategic Action Plan: 2019-2025[64], with nature, wildlife and birding, culture and heritage, exploration and active tourism and educational travels activities.

Area of impact

The impact of tourism is visible **at the mouthpiece of the Essequibo River and the Demerara river, in the center of the country with the Irokwama center, in the south-eastern part with Kaiteur waterfalls and in the south west close to Kanuku Mountains, and the south Rupununi district**. With five airstrips, the western/southern part of the country, inner zones are relatively well accessible (compared to its neighbor French Guyana for instance), with the intention to increase the air travel capacity. In 2014, two new Latin American airlines introduced flight which supplemented the introduction in 2013 of LIAT flights to and from Caribbean countries and Suriname. In that year, hotel room capacity will increase with the opening of 197 room at Marriott Hotel for instance.

---

[63] *Caribbean and Latin American countries that focused more on the coastal tourism (surf, beaches, etc.)*
[64] *Tourism-Strategy-2018-2025.pdf (business.gov.gy)*

Figure 31 Guyana's natural resources and infrastructures. Source: Wenner et al., 2015

Description of impact

Tourism has both positive and negative impact in Guyana.

- Ecotourism and community-based tourism are among the **positive dynamics in terms of natural resources management,** *bringing financial* sustainability for biodiversity and resources management, and a responsible access to wilder places as the service consumed is supposed to be *« environmentally responsible travel and visitation to relatively undisturbed natural areas »* (Ceballos-Lascuráin, IUCN, 1996).

The country also involves the indigenous communities into the management of protected areas, which has been recognized key for effective conservation. Traditional knowledge is generally based on complex cosmogonies going beyond the simple separation between nature and culture and **integrating the notion duty-bearers in relation to the environment, before the one of rightsholders** (See Janki, 2009; Campese et al., 2009; and, more broadly, Lausche, 2001; IUCN, Governance of protected areas from

understanding to action, 2013[65]). Studies done in Latin America also highlighted the awareness of this relationship of dependence between their way of life and conservation of the services their ecosystems provide (Cicchón, 2007).

Nevertheless, the legislative and policy framework still doesn't effectively incorporate the indigenous communities and do not recognize indigenous sovereignty for their resources and culture, which is **highlighted as a hurdle** (Sinclair, 2003). It results in a change in the traditional way of life of indigenous communities (knowing how to protect nature) as they often adjust it to accommodate for mass tourism.

As regards the negative effects of tourism on biodiversity, it lies in **scale level**, the frequency rate being the tipping point.

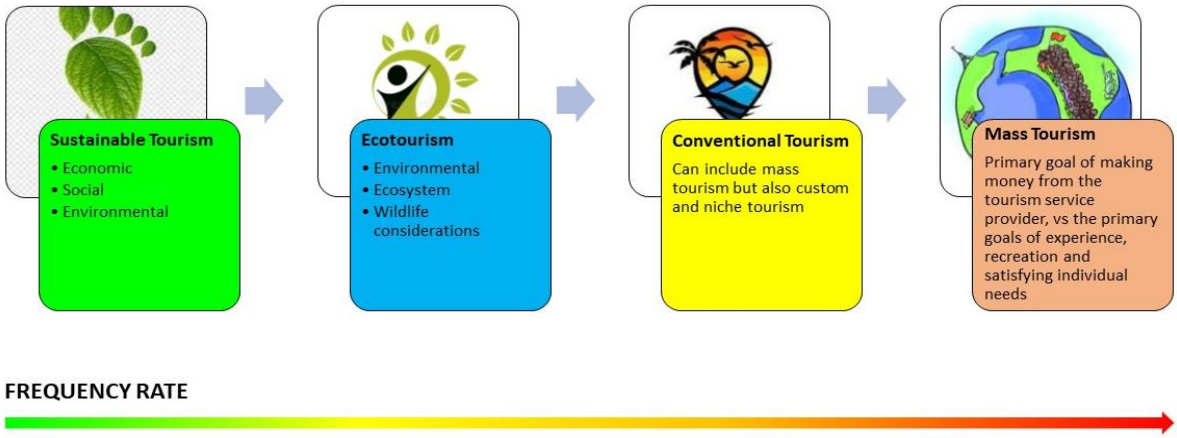


Figure 32 Types of tourism and their frequency rates

To assess the impacts of tourism on biodiversity, several variables should be considered: **the absolute value of frequentation, the intensity of pressure, but also its dispersion in space and its evolution over time** (Blanc et al., 2007a). Those variable aim to estimate the carrying capacity of a site, which corresponds to a level of impact beyond which its sustainability is compromised. It is defined by a **maximum number of visits per unit of area and time**, and varies according to the size of the site, interactions between users and the resistance and resilience of the environment. More generally, tourism (whether sustainable of not), has direct impact on habitats, species and wildlife due to those following drivers:

- **Transportation, accommodation, trails and developments** to access remote area

These developments made by and for humans concentrate recreational activities and channel users by avoiding their dispersal (Hrnciarova et al., 2018). However, as soon as the trail is established, it involves **habitat fragmentation and edge effects**. These disturbances induce **microclimatic changes, reduce dispersal and migration, and increase predation** (Jordan, 2000). Whether it is concentrated or diffuse use, studies show that there are impacts on the biocenosis, the biotope and sometimes the aesthetic attractiveness of the site (Blanc et al., 2007b; Hrnciarova et al., 2018). These impacts can spread outside the areas visited (Blanc et al., 2007b).

As regard species, **changes in abundance, community composition and population dynamics** are often the first impacts that come to mind. Indeed, populations of the most sensitive species decline or disappear from disturbed sites and community composition drifts from a natural biocenosis to a secondary's vegetation with opportunistic, ruderal, or human commensal species (Hrnciarova et al., 2018). However, **invasive alien species (IAS)**, their introduction and colonization are a secondary effect

[65] *https://www.iucn.org/sites/dev/files/content/documents/governance_of_protected_areas_from_understanding_to_action.pdf*

and are correlated with a chain of factors (Tonnesen & Ebersole, 1997; Sun & Walsh, 1998; Jordan, 2000). Species richness of alien species declines with increasing distance from the trail (Tyser & Worley, 1992), disturbance favors the establishment of IAS (Kowarik, 1999) and their numbers increase proportionally with the number of visitors (Lonsdale, 1999).

- **The rise of interaction between wildlife and humans** is also driver of biodiversity loss on the long term.

Wildlife is disturbed by human intrusion (Blanc et al., 2007b). Wildlife movements can be limited for species that avoid open areas with bare ground (Jordan, 2000). The provision of food (Jordan, 2000) leads to a **change in behavior**, in terms of **predator/prey relationships**, and in populations, with the **arrival of commensals** such as rats or rock pigeons. Furthermore, humans are passive vectors in the **dispersal of pathogens** (Sun & Walsh, 1998) for both fauna and flora.

Overtime is the frequency rate rise, non-sustainable practice can also **slowly change the requirement level for nature protection thresholds**, as regard wastes for instance. Statistically the more people there is, the more wastes also, and the capacity to manage it might be lower than the overwhelming of the carrying capacity.

The list of key drivers of biodiversity loss for the tourism industry are the following

- Sustainable resource management (positive)
- Mismanagement and non-compliance with the carrying capacity (direct)
  - Pressure on ecosystems
  - Increasing of waste, noise, any disturbance
  - Introduction of pathogens
- Transportation, accommodation, trails and other developments to access remote areas (direct)
  - Habitat fragmentation and edge effect
  - Microclimatic changes, reduction of dispersal and migration, increasing of predation
  - Change in abundance and population dynamic
  - Introduction of invasive alien species
- Rise of human-wildlife interactions (direct)
  - Disturbance of wildlife
  - Change in behavior (predatory/prey relationships)
  - Arrival of commensals
  - Dispersal of pathogens

C.7 Infrastructures linked to renewable energies

Contribution to national economy

Since 2009, the first steps toward the development of renewable energies were launched through the Low-Carbon Development strategy, which aimed to **reduce Guyana's dependancy on oil importation by developing those alternative sustainable sources of energy**. Later on, in 2019, Guyana's administration signaled its intent to transition towards renewable energy by 2040 through its Green State Development Strategy, and in that same year, **18% of the country's primary energy supply was already derived from renewable energy mainly from biogas (sugarcane), solar and firewood (GEA, 2019)** with opportunities also identified for wind power and hydroelectricity.

In terms of **solar energy, the country has a high potential**, with an annual daily global horizontal irradiation, receiving average irradiation of 1,800 kWh/m2 annually (Energy Sector Management Assistance Program, ESMAP). Solar energy is used for several purposes including for drying agricultural produce, irrigation, Information and communication technologies (ICT) and improvement of electricity

access in rural areas (ex: the Hinterland Electrification Programme) (GEA, 2021). Rooftops of 175 public or government buildings are also equiped with solar energy, and a series of solar PV Farms, totaling 5.2 MW is planned for Bartica, Lethem, Mahdia, Port Kaituma, Kwakwani and Matthew's Ridge, one solar farm being already operational in Mabaruma. Solar energy is then a sector that is growing. There is even **fiscal incentives include VAT and import duty exemptions** for renewable electricity equipment, solar appliances, solar water heaters and solar cookstoves, one-off tax holiday of two years for corporation tax to importers of items for solar energy investments, and a change of the Wear and Tear Schedule of the Income Tax Act to allow for the write-off of capital expense within 2 years (GEA, 2021; IRENA, 2015). The GEA also announced the willingness to promote **energy diversification in the transport sector**, with pilot project setting up electric vehicle with accompanying solar panels and energy storage system. Long term PPA's are also incentive format to catch for investors.

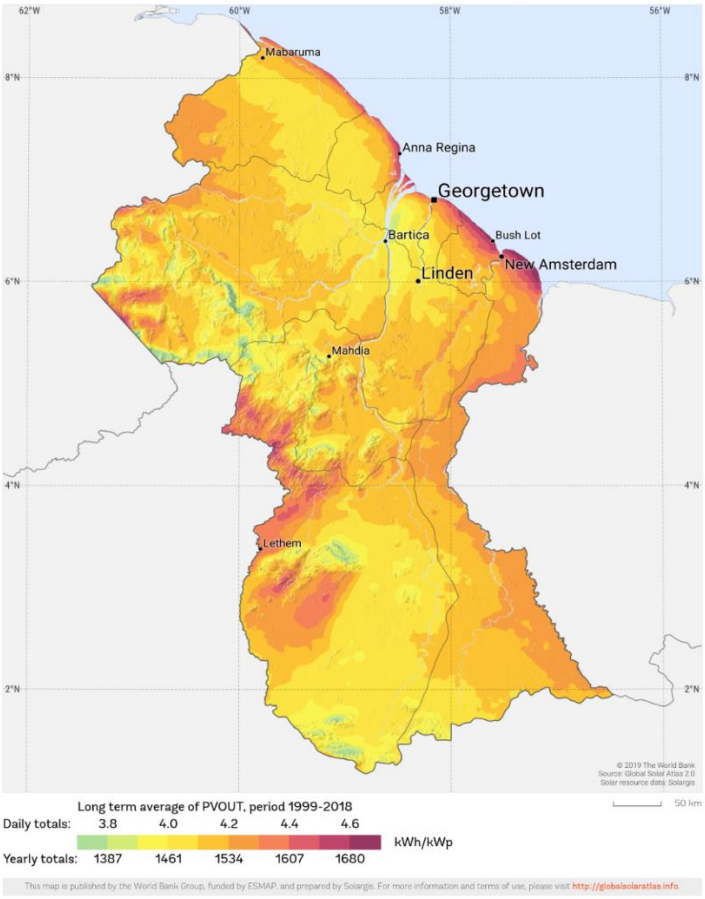


Figure 33 Solar Resource Map of Guyana: Photovoltaic Power Potential Source: World Bank Group & ESMAP

As regard hydroelectricity, **the 165MW Amaila Falls hydropower project** has been the first to be developed (along with the high pressure 30MW biomass, sugarcane bagasse, cogeneration plant as part of the Guyana's state-owned utility (GPL) Development and Expansion Programme 2013-2017). It includes private investors, China Development Bank and IADB, and to do so, the substantive Hydroelectric Power Act and Regulations (1956) have been revised several times (in 1973, 1988, 2013) and are likely to be still updated and revised.

Several other projects are underway, the 4,500MW hydropower project (GEA, 2021):

- the rehabilitation of the 0.5 MW Moco-Moco
- the 1.5 MW Tumatumari hydropower stations
- the rehabilitation of the 3MW Wamakaru hydropower site (finance by a private company)
- the rehabilitation of the Hosororo Hydropower Project (financed by the GIZ)
- the Kumu Hydropower Project: installation of a 1.5 MW hydropower plant and construction of a transmission line.

- the Ikuribisi Hydropower Projet: installation of a 1 MW hydropower plant and construction of a transmission line between the plant and the Bartica Power station

In 2021, it is estimated that there is a potential for **67 hydropower sites** in Guyana[66].

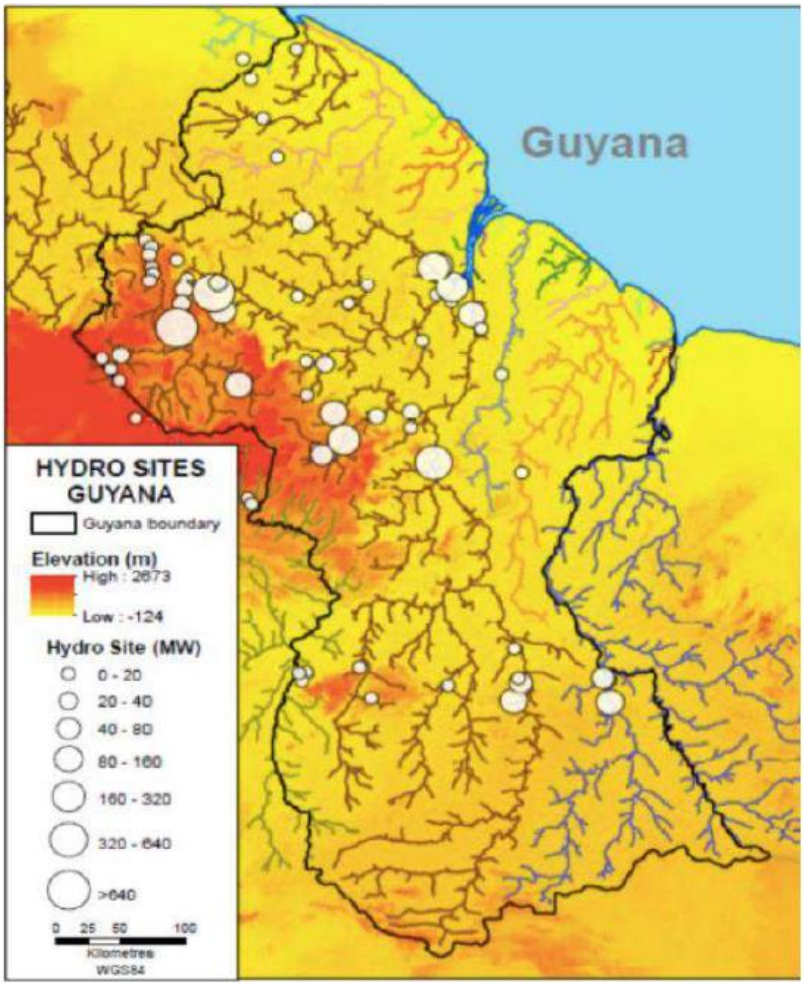


Figure 34 Guyana Hydroelectric Resources Source: Guyana Energy Agency, 2021

As regard wind-based energy, a wind farm with an installed capacity of about 10 MW is prepared for Hope Beach. Wind maps has recently been created by GEA's Energy Engineer using GIS software (ESRI Arcmap) to obtain wind speed measurements over years. As part of the IDB-GEF Sustainable Energy Program, **4 sites of interests have been found**. This sub-sector is thus at its very first steps.

[66] *https://gea.gov.gy/energyDev/Potential%20hydropower%20sites.pdf*

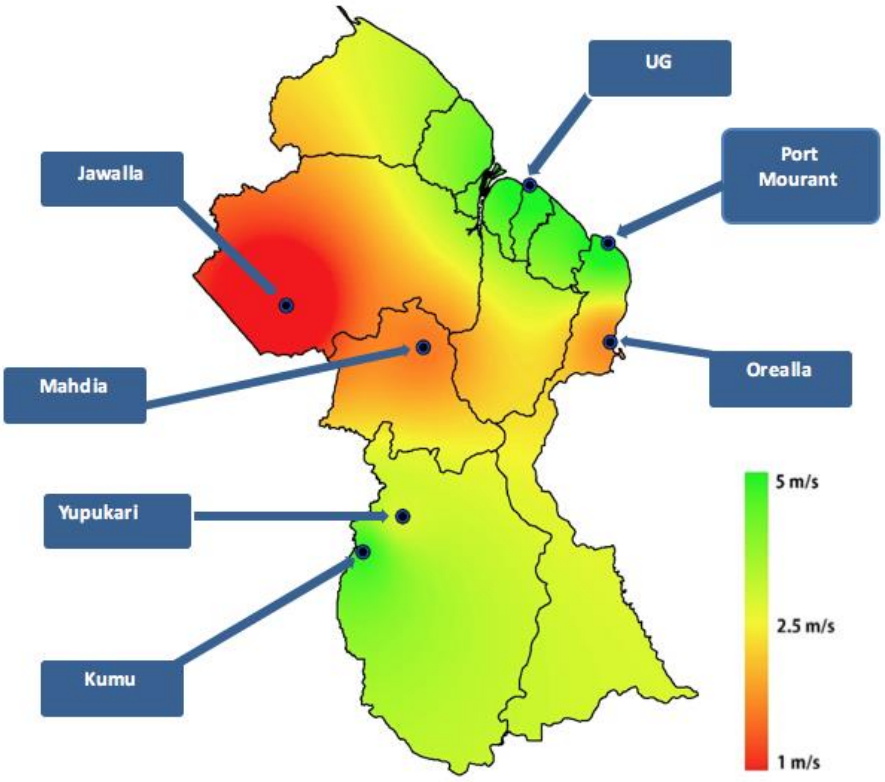


Figure 35 Wind speed potential across Guyana Source: Guyana Energy Agency, 2016

Area of impact

While the area of impact of the solar energy sector is low, the one of hydropower is quite high as regards the **water system and forest ecosystem** (especially down the montanes). As regard wind energy sector, it is still in development but **might impact the coastal ecosystem and the montane-submontane ecosystem.**

Description of impact

There is no study or research papers describing the impact of this sector in Guyana particularly. However, they can be predicted, based on what have been seen in other countries. Impacts can be both positive or negative, the main one being interferences in landscapes.

- **Infrastructure's settlements** is a direct driver of biodiversity loss

For solar and wind energy, the **fragmentation of habitat** will be detrimental to biodiversity by disturbing both flora and fauna (wildlife). **Noise pollution** is an issue as regard wind-based energy, and solar infrastructures could lead to the disruption of local micro-climate (European Comission, 2016; Suuronen et al., 2017), which could affect the fundamental plant-soil processes that govern carbon dynamics (Armstrong, 2014[67]).

As regards hydropower energy, habitat is generally the **disappearance of ecosystems** (when dams are impounded) and/or fragmentation of habitats, the disruption of water flows upstream and downstream of hydropower facilities, the **deterioration of water quality** due to changes in sediment load, turbidity and eutrophication.

[67] *https://pubmed.ncbi.nlm.nih.gov/24132939/*

- **Collision with fauna** is the second direct driver of biodiversity loss

For wind related infrastructures, **the collision of birds and bats with wind turbines**, and it affects not only local species but also migratory species, with disruption of migration routes (IDB 2012[68], Thaxter et al., 2017[69], Tesfahunegny, 2020[70]).

For bats, this can result in internal trauma (barotrauma) associated with sudden reductions in air pressure near the blades. As regards hydropower infrastructures, the fish taxa is the most impacted by the disruption of migration route of some fish species (Freyhof et al., 2020[71], Beck, C., 2020, Meister, J. 2020[72]). As regard solar infrastructure, birds are generally impacted, through exposure to intense solar flux, collision with installations, and might be disorientated by the intense or polarized light (Clifford K. Ho, 2016[73], Sisodia et al., 2019[74]) which is the same problem for insects. Ecological traps can also occur, due to cumulative attractant mechanisms.

- **Pollution** is the last driver of biodiversity loss for this sector

This section particularly concerns the **solar infrastructures**. Toxic chemicals are generally used to treat solar panels and soils (herbicides), which highly pollute water systems. Also, at the origin (construction), solar panels are (for the majority) made of **silicium**, the major constituent of Lithosphere, which exploitation generate a great amount of Suspended Particulate Matter. These particles get accumulated on leaves and thus they **disturb the photosynthesis and respiration process**. Later on, rain water ponded in unfilled mines percolates downward thereby (contaminating the ground water) and surface run-off of muddy water changes the nature of external water bodies and causes water borne diseases (Mishra, 2015[75])

Indirectly, **the shifting from fossil fuel energy dependency could have a positive impact.** Nevertheless, this last point is objectionable as Guyana now engaged in a large exploitation of oil wells.

The list of key drivers of biodiversity loss for the renewable energy sector are the following

- Infrastructure settlements (direct)
  - Habitat fragmentation or loss
  - Disturbance of fauna (including noise pollution)
  - Microclimatic changes
  - Disturbance of water flows
- Collision with fauna (direct)
  - Disruption of migrating routes
  - Loss of bats, birds and fishes
- Pollution (direct)
  - Deterioration of water quality
  - Silicium extraction for construction (doesn't directly impact Guyana)

C.8 Banking sector

Contribution to national economy

[68] *https://publications.iadb.org/en/bird-and-bat-collision-risks-wind-energy-facilities*
[69] *https://royalsocietypublishing.org/doi/10.1098/rspb.2017.0829*
[70] *https://basicandappliedzoology.springeropen.com/articles/10.1186/s41936-020-00171-1*
[71] *https://balkanrivers.net/Threatened_Fish_MedBasin.pdf*
[72] *https://www.waterpowermagazine.com/features/featuretowards-more-fish-friendly-hydropower-plants-8512234/*
[73] *https://www.osti.gov/servlets/purl/1364837*
[74] *https://link.springer.com/article/10.1007/s11356-019-06100-2*
[75] *https://academicjournals.org/journal/JGRP/article-full-text-pdf/915EC0C53587*

The growing responsibility of banks in the destruction of nature is increasingly raised (Bankrolling extinction, Portfolio Earth, 2019). In 2019, a study showed that the world's 50 largest banks are estimated to have invested some US$ 2.6 trillion in sectors now considered by governments and the scientific community to be the main drivers of biodiversity loss, with 66% for activities with **direct impacts (fishing, mining etc.)**, and 34% creating **indirect impacts.**

In the case of the said developing countries as Guyana, where there is not national financial resource, human activities are nearly fully financed by the international banking sector. Its environmental management capacity all belong to those funds, mainly coming from the British Overseas Development Agency (who worked on the forest policy), the German Agency for Technical Cooperation (who provided GIS systems), the Inter-American Development Bank (who financed the environmental protection agencies and other commissions), and the World Bank (which orientate the formulation of policies and invest in massive infrastructure projects) (Lakhan et al., 2000).

Recently, a documentary was also published to highlight controversial engagements of the World Bank in Guyana, both highlighting the country as being one of the most vulnerable to sea-rise level, and financing the development of the **oil and gas industry** by allocating one third of its budget for Guyana to the strengthening of public capacity to manage this oil rent (Shane Thomas Mac Milllan, 2019[76]). In fact, since the discovery of Exxon Mobil, the world bank is giving public assistance to increase investment in oil&gas sector, spending US$ 2,2 million to hire the law firm Hunton Andrews Kurth under a consultancy contract to draft new laws, this firm being the law firm from Exxon Mobil.

Area of impact

There are no specific areas of impact, but a **systemic impact**. The banking sectors has the great power to impose a governance models by developing economic models. The current trend of banks is to monetarise nature, and not to create a motion of development as **ecogrowth.**

Description of impact

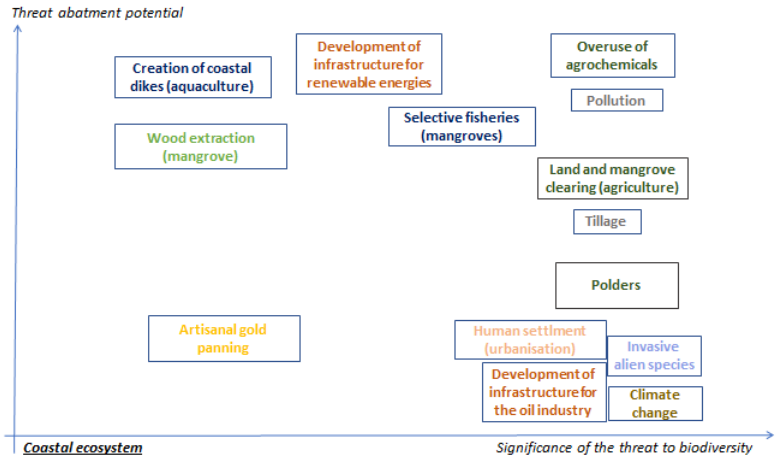
The impact is mostly indirect, **by driving demand within the supply chain for retail or resource processing and trade, such as the construction sector which creates demand for raw materials**. However, it is poorly documented. A study comparing the amount of money going to ecological performance rather than economic performance in the country would be worth to be done.

D. Drivers of biodiversity loss

Those preliminary results are the synthesis of the work being done below and will be completed through multi-stakeholders' interviews that will be held during the month of October.

[76] *https://news.mongabay.com/2020/11/guyanas-future-and-challenges-in-oil-qa-with-filmmaker-shane-thomas-mcmillan/*

D.1 Coastal plain (including mangroves)

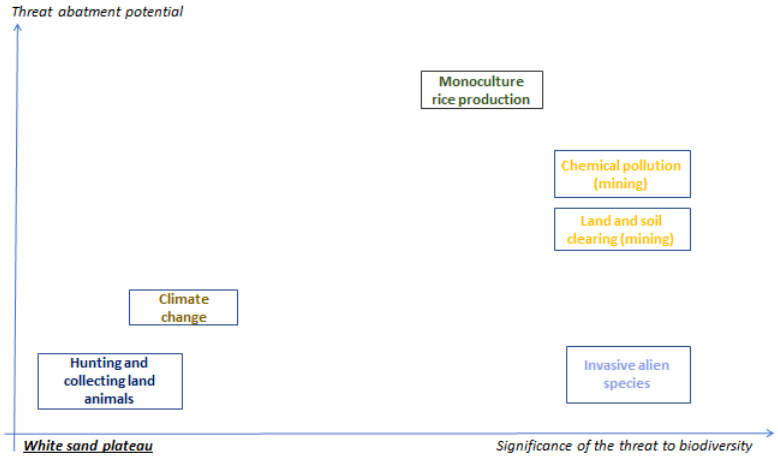


On the coastal ecosystem the main source of pressure is human settlement and urbanization as a result of the concentration of the economic activity. 90% of the population is living on the coast, close to employment centers in the following sectors:

- Agriculture
- Fisheries
- Oil and gas
- Mining
- Renewable energies

In the future, the coast is also increasingly threatened by the development of oil&gas sectors. Although offshore, the development of the oil activity will imply the construction of infrastructures on the coast, for the activity itself, and for the workers, who will migrate where the work is in demand.

D.2 The white sand plateau

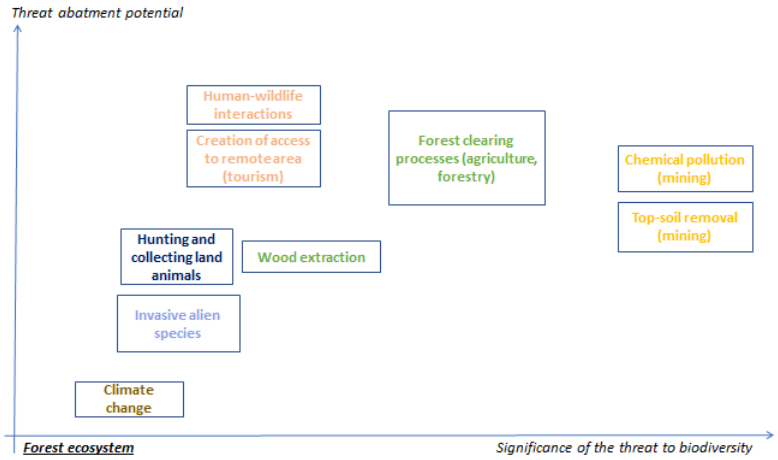


On the white sand plateau, the main driver of biodiversity loss is the mining sector. This ecosystem is known as being the Bauxite belt of the county, and the source of various minerals. The second driver is

agriculture, especially rice production, on the eastern part of the white sand plateau. This area is also a potential interesting one for forestry activities.

- Mining
- Agriculture
- Forestry

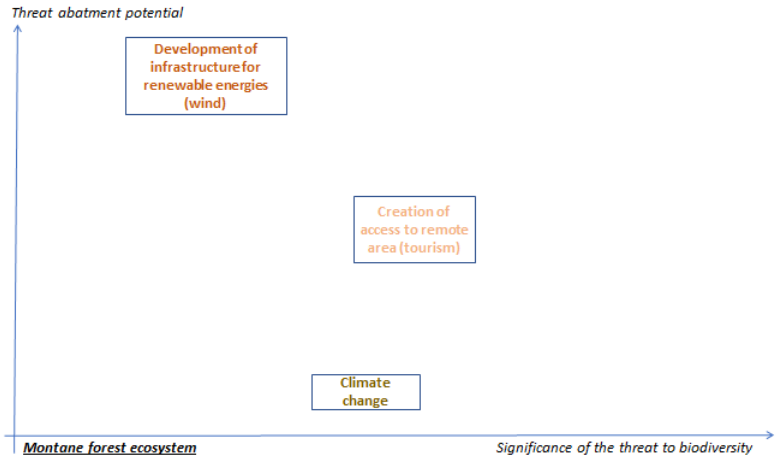
D.3 Forest ecosystem (excluding montane forests)



In the forest ecosystem, the main drivers of biodiversity loss are due to the following sectoral activities

- Mining
- Forestry
- Tourism

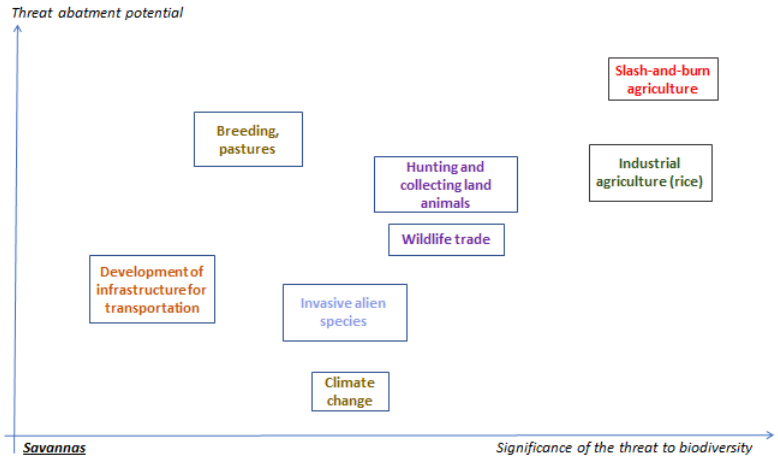
D.4 Highlands, mountains, plateaus



In highlands, mountains and plateaus the main drivers of biodiversity loss seems to be climate change, which is independent from sectoral activities. However, the tourism industry is an increasing threat, as if Guyana decide to diversify its ecotourism offer, mountains might be targeted. Renewable energy could also be a threat in the future, especially wind energy infrastructure, but it is not quite developed yet.

- Tourism (future)
- Renewable energies (future)

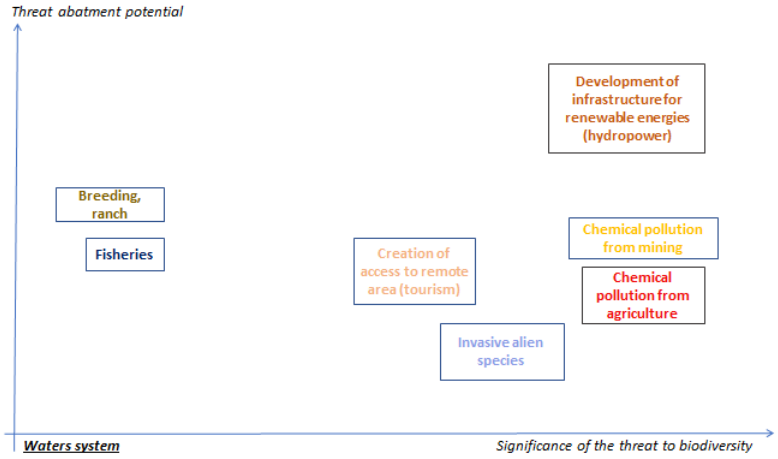
D.5 Savannas



Among the sectoral activities chosen, savannahs are mainly threatened by agriculture with the recent opening of a mega-rice farm and the traditional practices of slash and burn agriculture. In parallel, the hunting and collecting of land animals as well as the wildlife trade is also a source of pressure on the biodiversity. Savannahs are also key area to sustainable economic models.

- Agriculture

D.6 Water system (including freshwaters)

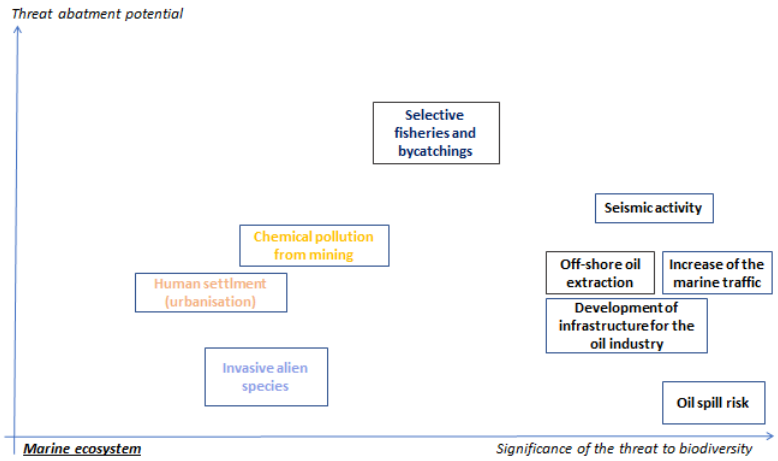


As regards freshwater systems, the main sectoral drivers of biodiversity loss are linked to:

- Mining
- Agriculture
- Renewable energies (hydropower)
- Tourism

Freshwater system receives and disseminate various pollutions coming from the mining and agricultural sectors and renewable energies is a growing sector especially the hydropower sector.

D. 7 Marine ecosystem



In the marine ocean, the main drivers of biodiversity loss are linked to the following sectoral economic activities:

- Oil and gas
- Fisheries
- Mining (indirect

E. References

Alonso, J. Á., Metz, M. R., & Fine, P. V. A. (2013). Habitat Specialization by Birds in Western Amazonian White-sand Forests. Biotropica, 45(3), 365–372. https://doi.org/10.1111/BTP.12020

BoS. (2018). Guyana Labour Force Survey. https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/GLFS_2017_Quarter4_Final-PDF-1.4MB.pdf

Briceño, H. O., & Schubert, C. (1990). Geomorphology of the Gran Sabana, Guayana Shield, southeastern Venezuela. Geomorphology, 3(2), 125–141. https://doi.org/10.1016/0169-555X(90)90041-N

Bulkan, J. (2013). The struggle for recognition of the indigenous voice: Amerindians in guyanese politics. Round Table, 102(4), 367–380. https://doi.org/10.1080/00358533.2013.795009

Clare, E. L., Lim, B. K., Engstrom, M. D., Eger, J. L., & Hebert, P. D. N. (2007). DNA barcoding of Neotropical bats: species identification and discovery within Guyana. Molecular Ecology Notes, 7(2), 184–190. https://doi.org/10.1111/J.1471-8286.2006.01657.X

Cole, C. J., Townsend, C. R., Reynolds, R. P., MacCulloch, R. D., & Lathrop, A. (2013). Amphibians and reptiles of Guyana, South America: Illustrated keys, annotated species accounts, and a biogeographic synopsis. Proceedings of the Biological Society of Washington, 125(4), 317–578. https://doi.org/10.2988/0006-324X-125.4.317

de Souza, L. S., Armbruster, J. W., & Willink, P. W. (2020). Connectivity of Neotropical River Basins in the Central Guiana Shield Based on Fish Distributions. Frontiers in Forests and Global Change, 0, 8. https://doi.org/10.3389/FFGC.2020.00008

Drugan, J. (2019). Environmental Sustainability Assessment: Guyana artisanal groundfish fisheries Executive summary. https://clmeplus.org/app/uploads/2020/06/Guyana-Environmental-Sustainability-Assessment_Artisanal-Groundfish-Fisheries.pdf

FAO. (2020a). Global Forest Resources Assessment 2020. https://doi.org/10.4060/ca9825en

FAO. (2020b). The State of the World's Forests 2020. The State of the World's Forests 2020. https://doi.org/10.4060/ca8642en

Gentry, A. H. (1992). Tropical Forest Biodiversity: Distributional Patterns and Their Conservational Significance. Oikos, 63(1), 19. https://doi.org/10.2307/3545512

Gibbs, A., & Barron, C. N. (1993). The geology of the Guiana Shield. Oxford University Press; Clarendon Press. https://www.worldcat.org/title/geology-of-the-guiana-shield/oclc/25747132

GoG. (2019). Annex A(3) Analytical Evidence to Support Guyana's Green State Development Strategy: Vision 2040.

Guyana Forestry Commission. (2018). Guyana Forestry Commission Guyana REDD + Monitoring Reporting and Verification System. October, 153. http://www.theredddesk.org/sites/default/files/resources/pdf/2011/guyana_mrvs_interim_measures_report_2010_final.pdf

Guyana Lands and Surveys Commission. (2013). Guyana National Land Use Plan. June. http://www.lands.gov.gy/National Land Use Plan GoG June 2013 with cover pages.pdf

Hance, J. (2008). 600 species of mushrooms discovered in Guyana. In Mongabay. Mongabay. https://news.mongabay.com/2008/07/600-species-of-mushrooms-discovered-in-guyana/

Henkel, T. W., Aime, M. C., Chin, M., & Andrew, C. (2004). Edible mushrooms from Guyana. Mycologist, 18(3), 104–111. https://doi.org/10.1017/S0269915X04003027

Henkel, T. W., Terborgh, J., & Vilgalys, R. J. (2002). Ectomycorrhizal fungi and their leguminous hosts in the Pakaraima Mountains of Guyana. Mycological Research, 106(5), 515–531. https://doi.org/10.1017/S0953756202005919

Hout, P. van der. (2016). Resource Assessment and Forest Management Plan for the CITES-Listed Species Cedrela odorata (red cedar) In Guyana . Report prepared for the Guyana Forestry Commission within the fra ... Resource Assessment and Forest Management Plan for the CITES-Listed. 1(October 2015).

Huber, O. (2003). Diversity of vegetation types in the Guayana Region: an overview. Plant Diversity and Complexity Patterns: Local, Regional and Global Dimensions. Proceedings of an International Symposium Held at the Royal Danish Academy of Sciences and Letters in Copenhagen, Denmark, 169–188. https://www.cabdirect.org/cabdirect/abstract/20073082421

Isaac, V. J., & Ferrari, S. F. (2016). Assessment and management of the North Brazil Shelf Large Marine Ecosystem. https://doi.org/10.1016/j.envdev.2016.11.004

ISSG. (2014). Global Invasive Species Database (GISD). http://www.iucngisd.org/gisd/legal.php

Jaikishun, S. (2017). Carbon storage potential of mangrove forest in Guyana. Bonorowo Wetlands, 7(1), 43–54. https://doi.org/10.13057/bonorowo/w070109

Kalamandeen, M., Gloor, E., Mitchard, E., Quincey, D., Ziv, G., Spracklen, D., Spracklen, B., Adami, M., Aragão, L. E. O. C., & Galbraith, D. (2018). Pervasive Rise of Small-scale Deforestation in Amazonia. Scientific Reports 2018 8:1, 8(1), 1–10. https://doi.org/10.1038/s41598-018-19358-2

Kekem, A. J. van, Pulles, J. H. M., & Khan, Z. (1996). Soils of the Rainforest in Central Guyana.

Luteyn, J. L., & Huber, O. (1993). El Macizo del Chimanta, Escudo de Guayana, Venezuela. Un ensayo ecologico tepuyano. Brittonia, 45(2), 183. https://doi.org/10.2307/2807506

NOAA. (2021). Deep-Sea Coral Habitat. NOAA Fisheries. https://www.fisheries.noaa.gov/national/habitat-conservation/deep-sea-coral-habitat

Maguire, B. (1973). Niche Response Structure and the Analytical Potentials of Its Relationship to the Habitat on JSTOR. The American Naturalist, 107(954), 213–246. https://www.jstor.org/stable/2459795

MoNRE, & EPA. (2012). Guyana's National Biodiversity Strategy and Action Plan.

Sarthou, C. (1992). Dynamique de la vegetation pionniere sur un inselberg en guyane francaise [Paris 6]. In http://www.theses.fr. http://www.theses.fr/1992PA066327

Schmid, R., Campbell, D. G., & Hammond, H. D. (1990). Floristic Inventory of Tropical Countries: The Status of Plant Systematics, Collections and Vegetation, Plus Recommendations for the Future. Taxon, 39(3), 464. https://doi.org/10.2307/1223097

ter Steege, H. (2000). Plant diversity in Guyana: with recommendations for a protected areas strategy. Tropenbos Series 18, 1–224.

Toft, J. D., Simenstad, C. A., Cordell, J. R., & Grimaldo, L. F. (2003). The effects of introduced water hyacinth on habitat structure, invertebrate assemblages, and fish diets. Estuaries 2003 26:3, 26(3), 746–758. https://doi.org/10.1007/BF02711985

US Engineer Corp. (1998). WATER RESOURCES ASSESSMENT OF GUYANA. https://www.sam.usace.army.mil/Portals/46/docs/military/engineering/docs/WRA/Guyana/Guyana WRA.pdf

van der Hout, P. (2000). Testing the applicability of reduced impact logging in greenheart forest in Guyana on JSTOR. International Forestry Review, 2(1), 24–32. https://www.jstor.org/stable/42609934

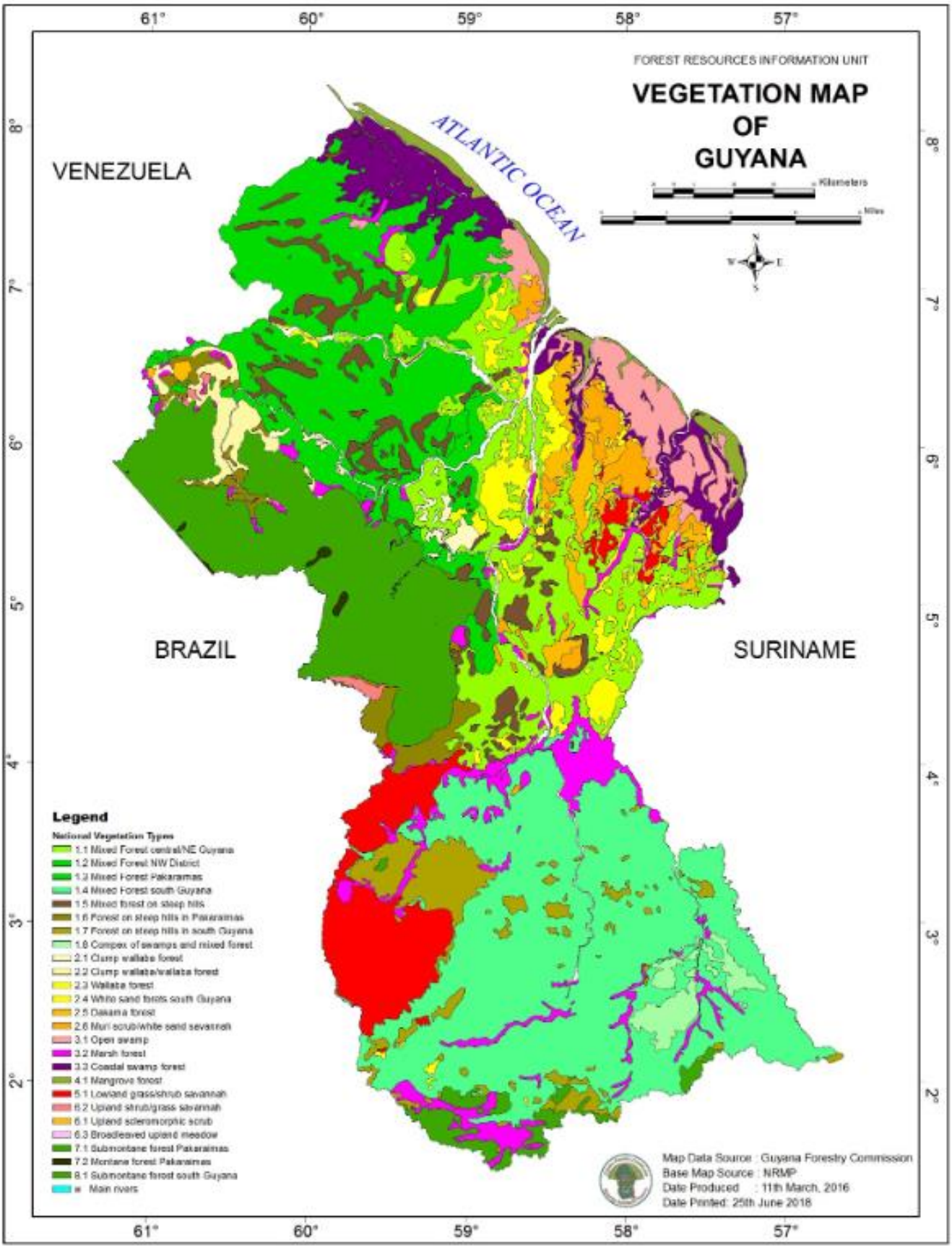
Vieira, L. T. A., Castro, A. A. J. F., Coutinho, J. M. C. P., de Sousa, S. R., de Farias, R. R. S., Castro, N. M. C. F., & Martins, F. R. (2019). A biogeographic and evolutionary analysis of the flora of the North-eastern cerrado, Brazil. Plant Ecology and Diversity, 12(5), 475–488. https://doi.org/10.1080/17550874.2019.1649311

Villamagna, A. M., & Murphy, B. R. (2010). Ecological and socio-economic impacts of invasive water hyacinth (Eichhornia crassipes): a review. Freshwater Biology, 55(2), 282–298. https://doi.org/10.1111/J.1365-2427.2009.02294.X

Willems, T. (2018). Impact of Guyana seabob trawl fishery on marine habitats and ecosystems: A preliminary assessment. https://fisheryprogress.org/sites/default/files/indicators-documents/Habitat%20and%20Ecosystem%20Report-Willems.pdf

World Wildlife Fund (WWF)-Guianas, 2012. Wetlands of Guyana – An insight into the ecology of selected wetlands with recommendations from WWF-Guianas.

ANNEX 1: Vegetation Map of Guyana



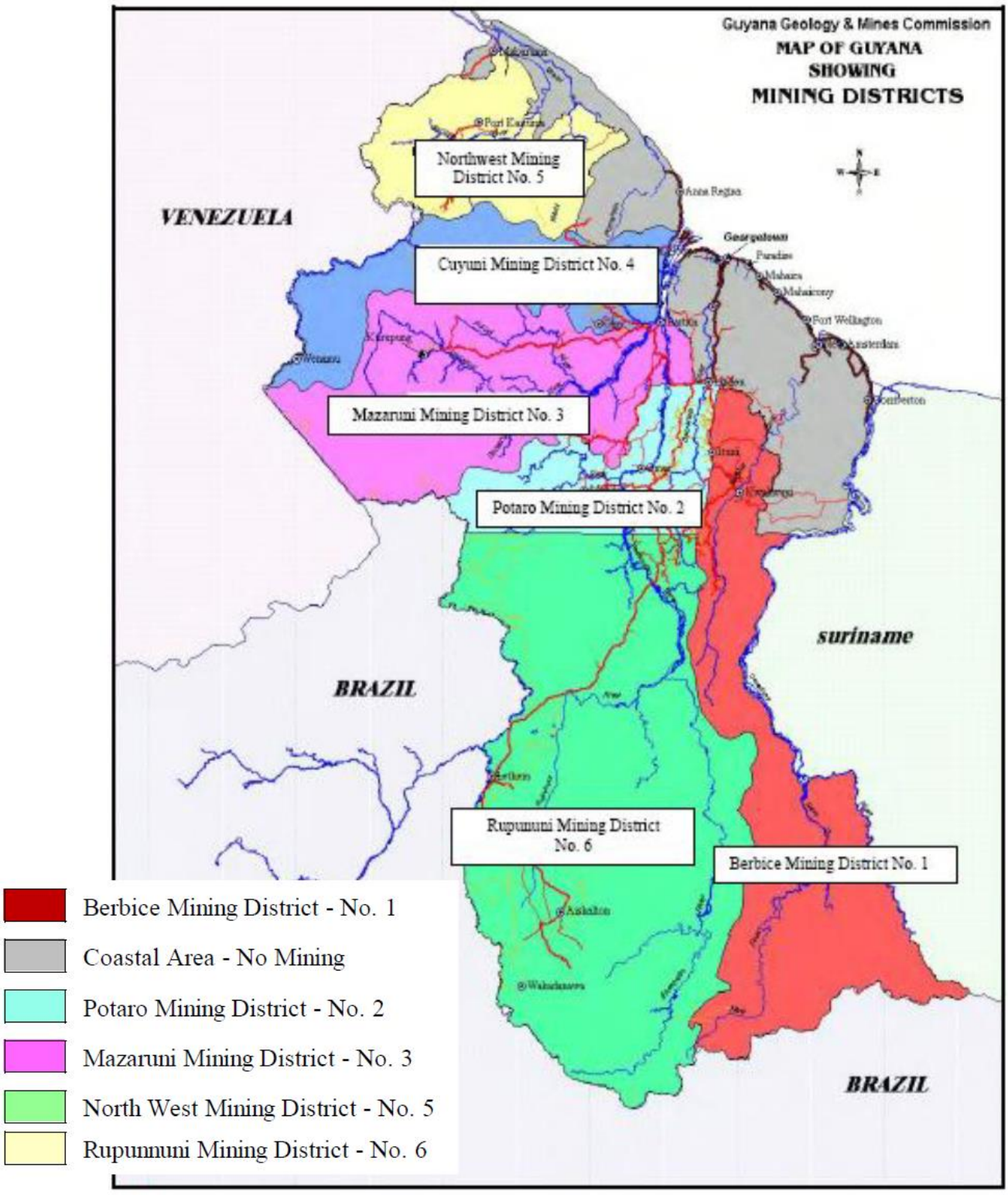
ANNEX 2: Mangrove Legislative Framework in Guyana

Legislation	Year	Remarks
Sea Defense Act	1998	Defined sea defense as (c, e)"All land fifty (50) feet landwards from the centre of any sea or river dam or sea or river wall and all land on the other side of such sea or river dam or sea or river wall in the direction of the sea or river to the toe of such sea or river wall ; and declares that "sea defense includes — any shell bank or reef, sand bank or reef or other natural feature which serves as a protection of the sea coast against the erosive action performed by the Ministry or its agents at the expense of the Board Sec.13 (1) and Sec. 16 (b) mandated to make regulations for (a) protecting the growth of Underwood, shrubs, and trees, on or near the foreshore or between high and low water marks (b) and the protection of the land and soil between high and low marks ; and generally, conserving the foreshore; and require estate to protect the foreshore by sowing seed, planting shoots to promote the growth of or the other tree, underwood, or shrubs, between and low water marks on the foreshore courida Sec.I3 (1 Sec. 14, 15 and Sec. 16 (b) (a) (b) Sec, 26 states that everyone who infringes any of the provision of this Act shall be liable on summary conviction of twenty-two thousand five hundred dollars (G$ 22,500)
Guyana Lands and Surveys Commissio n Act	2001	This Act establishes the Guyana Lands and Survey Commission as a body corporate. The Commission shall be the successor to the Lands and Surveys Department. Its functions shall be to take charge of and supervise all public lands, rivers and creeks in Guyana, to carry out various surveys of land and water resources of Guyana, to control and administer land surveys in Guyana, to establish and maintain a national survey control system, to evaluate offers for public land and to issue grants or leases
The Forests Act	2009	Part 3. 23 (b) prohibiting any disturbance of the soil, vegetation, rivers, or creeks in that specially protected area; and Part 3.31. (1) The Minister may by public notice make an order — (a) declaring any forest on private land to be a forest conservation area; and (b) prohibiting, restricting, or regulating all or any of the following - (i) entry into the forest conservation area (ii) cutting, damaging, taking, or removing any forest produce in the forest conservation area; (v) clearing, cultivating, or turning of soil in the forest conservation area; (vi) grazing or pasturing of livestock in the forest conservation area; (vii) setting of fire in the forest conservation area; (2) No order may be made except on the advice of the Commission that the order is necessary for — (a) conserving the forests of Guyana and securing the proper management of forest land; (b) preventing soil erosion, coastal erosion, or erosion of the banks of rivers or creeks; (c) preventing the deposit of mud, stones, or sand in rivers or creeks or on agricultural land; (d) maintaining water supplies in springs, rivers, canals, reservoirs, aquifers, or water conservancies; (e) minimising the risk or mitigating the impact of storms, winds, floods, or landslides Part 3.31. prohibits the cutting, damaging, or taking any forest produce, or carry out any other kind of forest operation in a State forest; occupy or use any land in a State forest Part 3.24., Part 3. 25 (2), Part 6. 68 b. (iv) section 25(2), section30(3), section 31(4), section 23(5)- prohibits person in any State forest to throw down a lighted match or lighted or inflammable material; or do anything else likely to result in any forest produce being burnt or damaged. Penalty range from GS250,000 to 1,000,000. Part 1. 5.3. state the Minister can declare public forested land as state forest

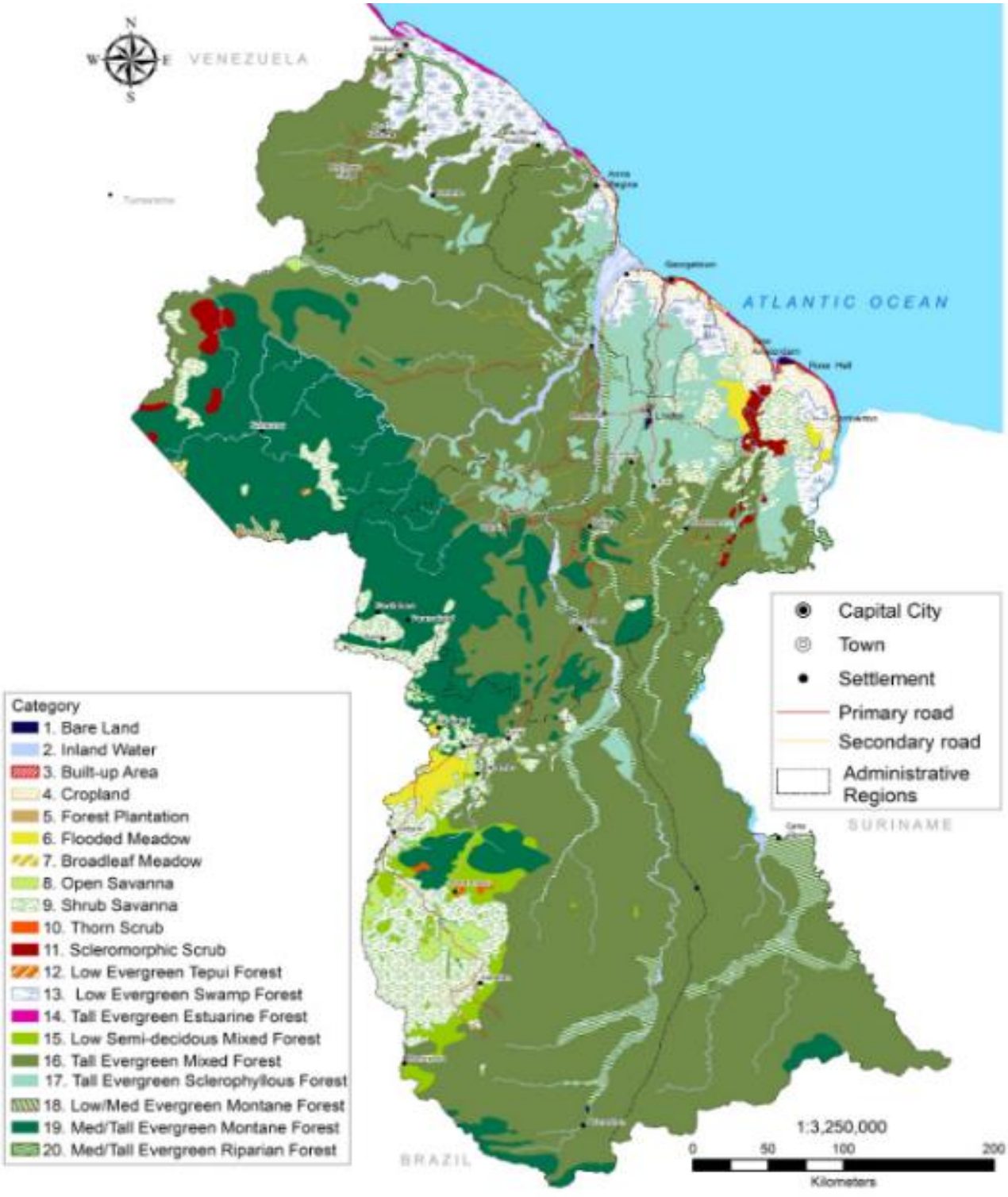
		Part 15.2 (b) (1) defines forest with reference to mangroves Part 3 Sec. 5.23. (1) mandates the EPA to declare a specific area of state forest to be a specifically protected area for a period not exceeding 25years (a) declare a specified area of State forest to be a specially protected area for a specified period not exceeding 25 years Part 3 Sec. 5.22 (1) is to I) conserve biological diversity 2) protect specific trees and plants 3) conserve soil and water reserves 4) protect forests from fires, pest, diseases and degradation Part 3. 5. 30 Minister can make order for protection of trees and plants any tree or plant, Part 3. 5. 31 Minister can declare private land to be a forest conservation area
The Environmental Protection Act	1996	Part 10.68.1 Minister may make regulations for giving the effect to the provisions of this Act for the protection of particular species of prescribed fauna and flora (j.) protecting the coastal and marine resources and establish, monitor and enforce the environmental regulations Environmental Protection Agency states that their functions are to take steps necessary for the effective management of the natural environment so as to ensure conservation protection, sustainable use of its natural resources; establish, monitor and enforce the environmental regulations; assessed environment impact of the project; and promote and encourage a better understanding and appreciation of the natural environment and its role in social and economic development
The Civil Law Act	1917	Article 4.3 states that no one shall remove any sand, shell, gravel, shingle or other mineral substances or any seaweed or vegetation from the lands without the permission of the Minister responsible for sea defences and are subject to the like penalties. Article 4.1 states from and after the date aforesaid, the foreshore of Guyana (that is to say, the part of the shore of the sea and of tidal navigable rivers which is covered by the medium high tide between the spring tides and the neap tides), the soil under tidal waters, and the sea-bed within the territorial waters of Guyana (hereafter in this section called “the lands”), shall be deemed to be State lands and may be dealt with in the same manner in which State lands are now dealt with under the State Lands Act or under any later Act.
Municipal and District Council Act	1970	Sec. 302(28). states the power of the council to regulate the cutting of wood on land vested in the council. Sec. 287,290 28). stated the power of the council to regulate the grazing of animals; impounding the stray animal found in public places
Local Government Act	1945	Part IV sec 51. (1) 51. (1) The local authority of any village or country district may, subject to the approval of the Minister, make by-laws with respect to the cutting of wood on the common lands of the village or country district and the fees to be paid therefor. Sec 50 states that grazing of animals on common land of the village and in country district will be impound and sec.102 (1-5) straying animals
Guyana Constitution	1980	Article 25 state that every citizen has a duty to participate in activities designed to improve the environment and protect the health of the nation.

		Article 74 (1) states that it is the duty of the Local Democratic to ensure in accordance with the law the efficient management and development of their areas and to provide leadership by example (3) to maintain and protect property, improve working and living condition and raise the level of civic consciousness. Article 36 states that in the interest of the present and future generation, the state will protect and make rational use of its land, mineral and water resources, as well as its flora and fauna, and will take all appropriate measures to conserve and improve the environment.
Local Democratic Organs Act	1980	Part 2. Sec. 7 Without prejudice to the generality of section 5, it shall be the duty of each local democratic organ and the members and officers thereof within its area— (a) to maintain and protect public property; (b) to protect and improve the physical environment; (c) to improve working and living conditions; (d) to stimulate economic activities and improve production and efficiency; (e) to promote the social and cultural life of the people; (f) to raise the level of civic consciousness; (g) to preserve law and order; (h) to consolidate socialist legality; (i) to safeguard the rights of the people; and (j) to give advice, encouragement and support to the people in their daily activities and to give leadership by example.
Fisheries Act	2003	Part VIII Sec. 21 (1) The Minister may, by Order, declare any area of the fisheries waters and, as appropriate, any adjacent or surrounding land, to be a marine reserve where he considers that special measures are necessary— (a) to afford special protection to the flora and fauna of such areas and to protect and preserve the natural breeding grounds and habitats of aquatic life, with particular regard to flora and fauna in danger of extinction; (b) to allow for the natural regeneration of aquatic life in areas where such life has been depleted; (c) to promote scientific study and research in respect of such areas; or (d) to preserve and enhance the natural beauty of such areas. (2) Any person who, without permission granted under subsection (3)— (a) fishes or attempts to fish; (b) takes or destroys any flora or fauna other than fish; (c) dredges, extracts sand or gravel, discharges or deposits waste or any other polluting matter, or in any way disturbs, alters or destroys the natural environment; or (d) constructs or erects any building or other structures on or over any land or waters, In any marine reserve, commits an offence and shall be liable on summary conviction to a fine not exceeding two hundred and fifty thousand dollars.

ANNEX 3: Mining Districts of Guyana



ANNEX 4: National Land Cover/Land Use Map



National Land use plan, 2017: https://glsc.gov.gy/wp-content/uploads/2017/05/Summary-Booklet-of-the-National-Land-Use-Plan.pdf

PROJECT	Analysis of drivers of biodiversity loss and impacting economic sectors in Guyana	
	World Wildlife Fund (WWF)	
	Biotope S.A.S. 22 Boulevard Maréchal Foch BP58 – F34140 Mèze FRANCE www.biotope.fr	
Editorial team	Fabien QUETIER fquetier@biotope.fr Manon BOUREY mbourey@biotope.fr César DELNATTE cdelnatte@biotope.fr Seon Hamer seonhamer0@gmail.com	
Control	Fabien QUETIER fquetier@biotope.fr	
Offer submission date	April 23rd, 2021	